Thriving under challenges – establishing individual and situational influences on eustress

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Abstract

Across four projects, I aimed to develop an in-depth understanding of how individuals experience eustress–the positive experience of a challenging situation. Specifically, I aimed to understand how eustress manifests in UK adults in general and in specific real-life situations. In Project 1, I performed a scoping review and deductive theory building to integrate 57 unique features of eustress from 80 articles into a Comprehensive Hierarchical construct of Eustress (CHE). According to CHE, eustress emerges from three main sources: successful goal-directed action, fulfilling momentary experiences, and positive stable qualities of the individual. In Project 2, I developed and assessed a novel eustress instrument, the Comprehensive Hierarchical Eustress Review (CHER), reflecting CHE's content and structure. In a quantitative study ($N = 260$), I found that the CHE model adequately described eustress in UK adults and provided insights into its relationships with distress and wellbeing. In Project 3, I established feature profiles of 20 difficult situations that likely induce eustress. I found that as UK adults ($N = 81$) judged a situation as increasingly threatening and challenging, they also judged it as more difficult and effortful with a less obvious solution and less effective coping. I found that a large language model could approximate general trends in human judgments but failed to reproduce meaningful relationships in the data. In Project 4, I combined insights from the previous projects to establish predictive profiles of eustress and explored how these profiles varied across individuals and real-life situations. In a quantitative survey ($N = 251$), I found that eustress emerges from individual-situation interactions, is predicted by the underlying processes of the CHE model and is weakly related to adaptive stress mindsets. I discuss the implications of my research regarding eustress theory development and measurement, as well as applied implications, limitations, and future directions for eustress research. By establishing a comprehensive construct of eustress and testing it across individuals and situations, this thesis may help formalize the small but growing research field on positive stress. Eustress is a complex behavior that is shaped by individual (e.g., fulfilment coping) and situational (e.g., intrinsic difficulty) processes as well as their interactions. I suggest that this research can be used to establish who experiences eustress under what circumstances, and what strategies are most effective in fostering positive stress where desirable and applicable.

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Declaration

This thesis contains the work conducted by Juliane Kloidt at the School of Psychology and Neuroscience, University of Glasgow, under the supervision of Prof Lawrence W. Barsalou, between September 2021 and October 2025. I hereby declare that except where stated, the work included in this thesis is my own, and no part has been submitted for any other degree at the University of Glasgow or any other institution.

Juliane Kloidt

Contributors Statement

Below are the contribution roles for each chapter of this thesis. Contributions are listed following the Contributor Roles Taxonomy (CRediT) format.

Key
JK: Juliane Kloidt, LB: Lawrence W. Barsalou, MB: Monika Balaya

Chapter 1
JK: Conceptualization, Writing – Original draft, Writing – Review and editing. LB: Conceptualization, Writing – Review and editing.

Chapter 2
JK: Conceptualization, Literature search, Formal analysis, Writing– original draft, Writing– review and editing. LB: Conceptualization, Formal analysis, Writing– review and editing, Supervision.

Chapter 3
JK: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review and editing. LB: Conceptualization, Methodology, Writing – review and editing, Supervision.

Chapter 4
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Chapter 5
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Chapter 6

JK: Conceptualization, Writing – Original draft, Writing – Review and editing. LB: Conceptualization, Writing – Review and editing.

List of Publications

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Abbreviations

- **AI** – Artificial Intelligence
- **AIC** – Akaike Information Criterion
- **ANOVA** – Analysis of Variance
- **BF** – Bayes Factor
- **BIC** – Bayesian Information Criterion
- **CAIC** – Consistent Akaike Information Criterion
- **CFI** – Comparative Fit Index
- **CHE** – Comprehensive Hierarchical construct of Eustress
- **CHER** – Comprehensive Hierarchical Eustress Review
- **CHER-Qual** – CHER subscale for Stable Qualities
- **EFA** – Exploratory Factor Analysis
- **ESS Wellbeing** – European Social Survey Wellbeing Module
- **HEXACO-60** – HEXACO Personality Inventory (60 items)
- **LLM** – Large Language Model
- **OR** – Odd Ratio
- **OSF** – Open Science Framework
- **PES-10** – Perceived Eustress Scale (10 items)
- **PSS-10** – Perceived Stress Scale (10 items)
- $\mathbf{R^2}$ – Variance Explained
- **RMSEA** – Root Mean Square Error of Approximation

- **RQ** – Research Question
- **SAM**^{2} – The Situated Assessment Method
- **SM** – Supplemental Material
- **SMM** – Stress Mindset Measure
- **TLI** – Tucker Lewis Index

Chapter 1

General introduction

1.1 Introduction

Stress is ubiquitous and therefore receives substantial public and academic attention. Current interventions focus on reducing and/or eliminating stress even though this is not always possible or desirable. Importantly, stress is not fundamentally destructive but can facilitate health, wellbeing, and performance (Crum et al., 2020; Jamieson et al., 2018; McEwen, 1998). Stress responses have therefore been split into maladaptive distress and adaptive eustress (Lazarus & Folkman, 1984; Selye, 1974). Whereas research on the negative effects of stress is well-developed (e.g., Epel et al., 2018; O'Connor et al., 2021; Schneiderman et al., 2005), there is a lack of integrated, comprehensive research on eustress theories, measurements, and interventions (Kloidt & Barsalou, 2024; Le Fevre et al., 2003). Therefore, this thesis aims to improve our understanding of eustress by using diverse quantitative research methods to integrate fragmented conceptualizations of the construct, comprehensively assess how UK adults experience eustress in real-life settings, and measure individual and situational influences on positive stress. I hope that this work can inform robust, contextualized theories of eustress and situated interventions that empower individuals to pivot from distress to eustress where applicable and desirable. Additionally, I hope that this work can contribute to a more balanced public and academic discourse on stress.

1.2 Chapter overview

This chapter aims to introduce important concepts, theories, and terminology I use throughout this thesis. I begin with justifying the focus of this thesis by evidencing the global burden of stress and the limited scope of stress interventions. I illustrate the paradoxical nature of stress and introduce key theories on distress and eustress. I next review existing eustress research to establish the current state of theories, psychometric

instruments, and interventions while illustrating limitations and knowledge gaps. I then present the current thesis, including the overarching aims and guiding principles that informed the research I conducted. Finally, I outline the specific aims and content of the empirical chapters that follow.

1.3 Global burden of stress

Stress—the non-specific bodily, cognitive, affective, and behavioral response to difficult situations—is central to the human condition (Selye, 1936, 1950, 1951). As stress pervades all aspects of our lives, it receives substantial public attention, for instance through best-selling books and movies, or through popular articles and podcasts. Stress has also been the focus of a large body of biological, epidemiological, and psychological research because—although not a clinical condition itself—stress is intricately linked to physical and mental health (for reviews, see O'Connor et al., 2021; Schneiderman et al., 2005).

In 1950, Hans Selye, a pioneer in stress research, stated that "anything that causes stress endangers life, unless it is met by adequate adaptive responses; conversely, anything that endangers life causes stress and adaptive responses" (Selye, 1950, p.1383). Since then, decades of research have accumulated evidence that stress can affect individuals' health directly through autonomic, immune, and neuroendocrine responses (Kivimäki & Steptoe, 2018; Segerstrom & Miller, 2004) and indirectly through changes in health behaviors (Hill et al., 2018; Tomiyama, 2019). The link between stress and health manifests in many countries across the world, where stress is a leading cause of long-term sickness, resulting in millions of working days lost (e.g., American Psychological Association, 2024; UK Health and Safety Executive, 2024). It is therefore not surprising that the World Health Organization declared stress as a 'world epidemic' (Aguiló et al., 2015), calling for effective interventions.

1.4 Current stress interventions

Numerous interventions exist that aim to prevent and/or reduce stress in individuals. Depending on their target mechanism, they have been categorized into primary, secondary, and tertiary interventions (Cooper & Cartwright, 1997; Hargrove et al., 2011; Tetrick & Winslow, 2015). Primary interventions aim to eliminate or at least modify sources of stress in the environment through system-level regulations (e.g., maximum weekly working hours) and individual-level restructuring (e.g., removing oneself from a stressful workplace). Secondary stress interventions detect and manage stress individuals experience through teaching skills, including mindfulness (Khoury et al., 2015), breath work (Fincham et al., 2023), or connecting with nature (Adewuyi et al., 2023). Tertiary stress

interventions offer treatment, such as cognitive-behavioral therapy, to help individuals recover from stress-induced ill health.

Albeit differing in their target (system vs. individual), mode of action (preventative vs. reactive), and behavior change techniques (e.g., restructuring the physical environment, behavioral practice), most stress interventions to date share a common goal: stress reduction. Whereas many interventions are effective in reducing stress (e.g., Rogerson et al., 2024), they may be limited for the following reasons. First, stressed populations and stressful contexts are highly heterogenous calling for contextualized interventions (Bryan et al., 2021). Some skills may be effective for some individuals in some situations but not for other individuals and/or other situations. Secondly, stress interventions tend to focus on reducing stress symptoms in the moment rather than changing fundamental stress habits. Lastly, using stress reduction as the key indicator of interventional success can be misleading because it is not always possible or desirable to reduce stress. Importantly, stress does not have fundamentally destructive qualities.

1.5 The stress paradox

From an evolutionary point of view, stress responses help individuals adapt to continually changing demands and therefore enable survival. Insofar as the stress response subsides once the environmental stressor is no longer present, it is an adaptive process, improving physiological and mental functioning (Sapolsky, 1996). When the physiological stress response persists over time, however, it can debilitate health and wellbeing (McEwen, 1998; O'Connor et al., 2021). Whether stress is beneficial or debilitating also depends on its level of arousal. The Yerkes-Dodson law (Yerkes & Dodson, 1908) proposes that moderate stress arousals are optimal for performance, thereby contrasting not only excessive arousal (potentially leading to mental overwhelm or anxiety) but also minimal arousal (potentially leading to apathy or feeling unmotivated). To capture the paradoxical nature of stress—that it can debilitate *and* facilitate performance, health, and wellbeing—Selye defined two types of stress: distress and eustress (Selye, 1974).

1.6 Distress and eustress

According to Selye (1974), bodily responses to different types of demands can lead to physiological maladaptation, defined as distress, or physiological adaptation, defined as eustress. Whereas Selye's original distinction between distress and eustress focused on non-specific physiological patterns (cf. Selye, 1936, 1950, 1951), the psychologists Lazarus and Folkman conceptualized distress and eustress as cognitive-affective processes. In their transactional model of stress and coping, individuals appraise difficult situations against

their coping resources (Lazarus, 1966; Lazarus & Folkman, 1984; Lazarus & Folkman, 1987). Distress results when the situational demands exceed the individual's available coping resources. Eustress results when the individual's coping resources meet the situational demands.

Although these models focus on physiological vs. cognitive-affective manifestations of distress and eustress, both Selye's adaptation syndrome and Lazarus and Folkman's transactional model define distress and eustress as responses to broad assessments of situational demands and individual resources. Distress and eustress are thus neither attributed to the situation (stressor) nor the individual alone but depend on the interactions between both. Through defining distress and eustress as stress responses, they remain separate from related constructs such as challenge and threat (attributes of the stressor) and stress mindsets (attributes of the individual).

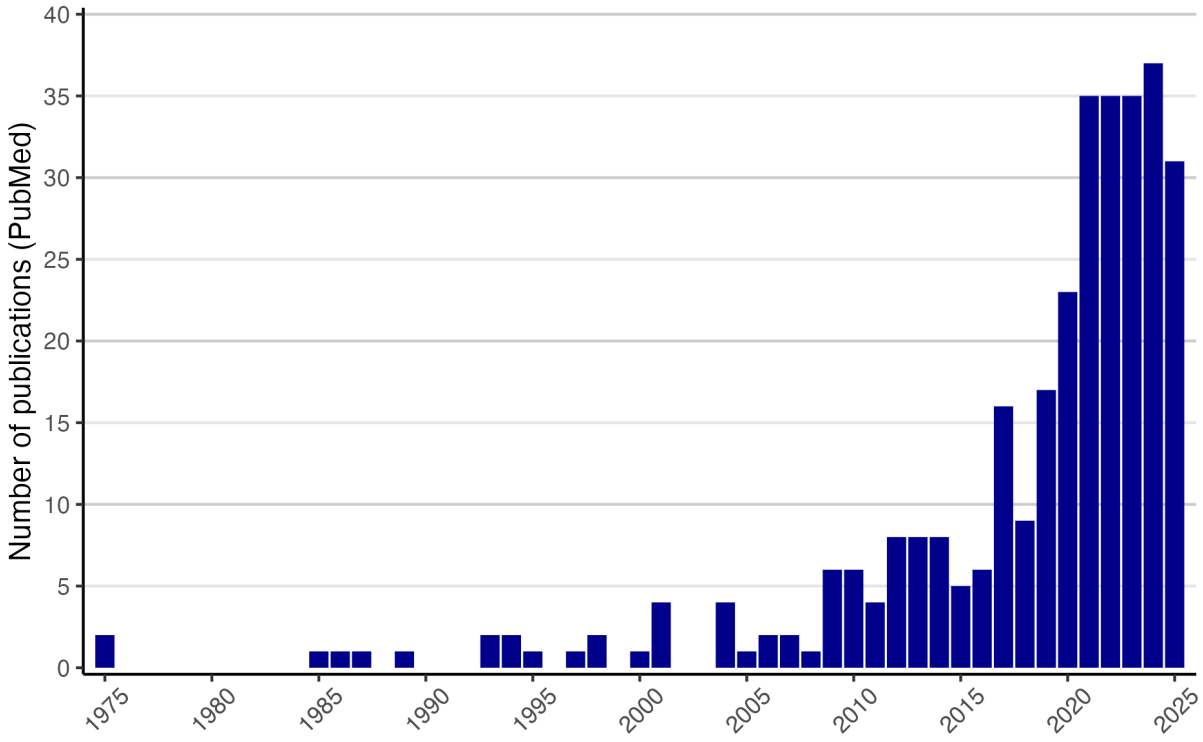
1.7 Current state of eustress research

Although Selye first distinguished between positive and negative stress over 50 years ago, most people equate stress with distress and therefore focus on reducing and/or eliminating it (Crum et al., 2020; Jamieson et al., 2018). For instance, when 300 US adults were asked to choose the best advice for an upcoming public speaking scenario, 91% of people opted for minimizing stress by staying calm and relaxed and only 8% opted for utilizing stress by being excited instead of anxious (Brooks, 2014).

The predominant view that stress should be avoided also persists in research. For instance, the PubMed database only retrieves approximately 320 articles that include "eustress" in their title or abstract (search date: October 7, 2025). In contrast, keyword searches on "distress" and "stress" retrieved more than 180,000 and 1.1 million journal articles, respectively. Nevertheless, Figure 1.1 illustrates that more than 60% of the eustress publications identified ($n = 196$) were published in the past five years. Eustress research is growing and becoming increasingly diverse, highlighting the importance of developing unified theories, comprehensive assessments, and effective interventions. This thesis focuses on eustress as a cognitive, affective, and behavioral construct. The following sections therefore review eustress theories, measurements, and interventions that conceptualize eustress accordingly.

Figure 1.1

Publications on eustress retrieved from PubMed since 1975



Note. Number of published articles in the PubMed database that include the term "eustress" in the title or the abstract. Data extracted from the PubMed database on October 7, 2025. Total number of publications = 318

1.7.1 Eustress theories

Since the term eustress was introduced as part of a general adaptation syndrome (Selye, 1974) and applied to the transactional model of stress (Lazarus & Folkman, 1984), cross-disciplinary research has begun to delineate its multidimensional character. Over the years, various research fields have developed theories of eustress together with distress. However, considerable variability exists regarding the focus, conceptualization, and separation of the construct (Kloidt & Barsalou, 2024).

Whereas most eustress theories focus on stress responses (e.g., Crum et al., 2020; Hargrove et al., 2015; Simmons & Nelson, 2007; Simmons et al., 2024), others attribute the valence of stress to the situation (e.g., Cavanaugh et al., 2000). Theories further present with different conceptualizations of eustress, including eustress as a positive affect (e.g., Simmons et al., 2024), regulatory process (e.g., Crum et al., 2020), or desirable cognitive state (Edwards & Cooper, 1988). Lastly, existing theories disagree about the relationship between eustress and distress, mapping them as mutually exclusive opponents (e.g., Cavanaugh et al., 2000) or as parallel processes (Simmons & Nelson, 2007).

As a consequence, theories of eustress are highly fragmented, even within the same

research field. Integrating these fragmented findings into a well-defined and unified construct of eustress would not only improve the scientific credibility of eustress and stress in general (for critiques, see Bienertova-Vasku et al., 2020; Kagan, 2016) but also support developing eustress measurements and interventions (Bringmann et al., 2022).

1.7.2 Eustress measurements

Similar to eustress theories, the development of psychometric instruments for measuring eustress remains at the early stages. Most stress instruments assume that stress is a negative state and are therefore not suitable for measuring eustress. One prominent example is the Perceived Stress Scale (PSS-10; Cohen et al., 1983). Most items of this scale are negatively valanced, and the few positively valanced items are reverse coded so that someone's overall score on the measure reflects their frequency of distressing experiences only (e.g., "In the last month, how often have you been upset because of something that happened unexpectedly?").

To-date, few eustress instruments exist (e.g., Cavanaugh et al., 2000; O'Sullivan, 2011; Rodríguez et al., 2013; Vikoler et al., 2024). These instruments are typically restricted to specific populations (e.g., students, managers, social workers) and/or specific contexts (e.g., workplace settings including universities, corporations, or social services). Consider the following examples: "The scope of responsibility my position entails" (workplace managers; Cavanaugh et al., 2000). "How often do you deal successfully with irritating academic hassles?" (university students; O'Sullivan, 2011). "Implications of mistakes you make" (social workers; Rodríguez et al., 2013). Using these instruments makes it difficult to compare results from different scales and to investigate how eustress manifests in a general population across all areas of life.

Most interestingly, none of the existing scales measure different features of eustress in specific situations where it occurs, even though the transactional model conceptualizes eustress as resulting from complex individual-situation interactions (Lazarus, 1966; Lazarus & Folkman, 1984; Lazarus & Folkman, 1987). More generally, a large body of research demonstrates that individuals exhibit large variability in behaviors across situations (Bandura, 1978; Cervone et al., 2001; Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021; Mischel & Shoda, 1995). Even still, existing measures are decontextualized, asking respondents to average across stressful situations in their lives and/or rely on implicit theories or the availability heuristic (Ajzen, 1977; Gelman & Legare, 2011; Tversky & Kahneman, 1973).

For these reasons, there is a need for comprehensive, theory-based instruments that evaluate eustress as a multi-dimensional concept in a general population across their stressful experiences. There is also a need for contextualized instruments measuring eustress across individuals and situations. Situated instruments can help identify situations with

high eustress potential and measure how individuals and situations interact to produce varied stress responses in the real world (cf. Dutriaux et al., 2023). Situated assessments of eustress offer high external validity that, in turn, can inform novel interventions.

1.7.3 Eustress interventions

Whereas most stress interventions reinforce counterproductive lay theories that stress should be avoided, some researchers have started to shift their focus from minimizing to optimizing it (Crum et al., 2020; Jamieson et al., 2018). For instance, strategies to optimize stress include adopting stable, trait-like beliefs that stress can be beneficial (Crum et al., 2013, 2017; Goyer et al., 2022; D. Park et al., 2018) and shifting stress appraisals from negative to positive rather than trying to eliminate them (e.g., Jamieson et al., 2012, 2016; Yeager et al., 2016).

In a recent intervention, Crum et al. (2023) provided participants with balanced information about the positive and negative effects of stress alongside information about the influence of their mindsets, intended to empower participants to choose a more adaptive mindset (stress is enhancing) even when facing conflicting information (stress is debilitating). Across three randomized experiments, participants in the "rethink stress" condition self-reported more adaptive stress mindsets and improved physical health and work performance compared to waitlist controls and to participants who received unbalanced information about the positive effects of stress only (Crum et al., 2023). Whereas the intervention contributed to a nuanced perspective of stress that produced promising effects, it required recipients to know *when* and *how* to apply their gained knowledge.

From the perspective of grounded cognition, eustress is not an independent process but deeply entrenched in the situations that the individual experiences (Barsalou, 2008, 2020; Glenberg, 2010). As eustress emerges from interactions between cognitive processes, perceptual modalities, the body, and the physical and social environment, the experience of eustress and the actions that follow from it are situated (Barsalou, 2019, 2020). When an individual experiences eustress similarly across a repeated situation (e.g., giving a public speech, flying trapeze), situated conceptualizations develop that drive conditioning, habit learning, and autobiographical memory (Barsalou, 2009; Lebois et al., 2020). Focusing on situated experience rather than situation-independent skills may therefore offer a promising starting point for contextualized interventions that guide individuals to build desirable stress habits in situations that matter to them.

1.8 Current thesis

Overall, this thesis aims to provide an in-depth understanding of how individuals experience eustress in real-life challenging situations and what factors influence its mani-

festations. I hope that this work can be used to develop new eustress interventions and tailor current stress interventions, empowering individuals to shift from negative to positive stress where applicable and desirable. Additionally, I hope to provide theoretical insights that inform future investigations of eustress or stress responses more broadly, and that contribute to a more balanced public discourse on stress. Specifically, I aimed to do the following:

1. Develop a comprehensive construct of eustress and identify features that are key to experiencing challenging situations positively.

2. Apply the comprehensive construct to assess how UK adults experience eustress in general across their challenging situations.

3. Identify and describe challenging and threatening real-life situations that likely provoke eustress.

4. Investigate how UK adults experience eustress in these situations.

The rest of this section describes the philosophical perspectives and scientific methods that informed the empirical work I conducted to obtain these aims. I also provide an overview of the research conducted in the four empirical projects (Chapters 2 – 5) that follow.

1.8.1 Guiding philosophical perspective

The research in this thesis is grounded in the assumption that social phenomena—such as eustress—are inherently shaped by individuals and contexts (Barsalou, 2008, 2009, 2020). Through adopting a critical realist philosophical stance this thesis aims to measure diverse manifestations of eustress and its underlying mechanisms across various situations rather than trying to uncover universal truths. By targeting UK adults, this research adopts an individualistic perspective on eustress that may generalize to similar populations but likely differs from collectivist cultures (cf. individualistic vs collectivistic wellbeing; Hendriks et al., 2019).

Similar to the notion that observed phenomena vary across individuals and contexts, this thesis also rejects the positivist assumption that scientific theories and measurements are value neutral (Van Zyl et al., 2023). Although this thesis focuses on eustress in individuals, it neither prescribes that stress is inherently good nor that individuals are to blame when suffering from stress-induced ill health. Instead, the research presented here aims to contribute to a more nuanced understanding of stress and highlights the influence of external environments on it. I note that this thesis employs quantitative research methods that are often viewed as reflections of positivist traditions. I therefore outline

in the next section how this research departs from hypo-deductive hypothesis testing and instead aims to develop a robust and contextualized theory of eustress.

1.8.2 Scientific method

This research was influenced by persisting debates about the method of psychological science. The pre-dominant method of psychological science is hypo-deductivism that designs statistical tests aiming to falsify deductive inferences of a hypothesis (Fidler et al., 2018). If a prediction survives repeated experimental tests that are capable to falsify it, then the underlying theory is "corroborated" by past experience (Popper, 1968). Findings from null hypothesis statistical testing, however, often failed to replicate, resulting in a crisis of replicability and confidence in psychology (Pashler & Wagenmakers, 2012). Reforms in reaction to this crisis not only targeted more rigorous methods (e.g., registered reports, preregistration, increased statistical power) but also emphasized the importance of developing robust theories before testing hypotheses (Bringmann et al., 2022; Scheel et al., 2021). The robustness of a hypothesis critically depends on its underlying "derivation chain" (Meehl, 1990). Even when hypothesis testing is robust, the empirical findings need integration into a theoretical framework to become relevant (Giner-Sorolla, 2019; Muthukrishna & Henrich, 2019).

Considering the current state of eustress research that I reviewed previously, I assessed that the field remained in early stages of theory development that could not support robust hypothesis testing. My research therefore intends to support a basic eustress theory, taking inspiration from Dubin's (1978) iterative steps for theory development (see also Scheel et al., 2021). To do so, the first aim of my thesis established a unified and well-defined construct of eustress. In the second aim, the resulting model was tested with a novel psychometric instrument that allowed quantifying relationships between eustress and relevant constructs. The third aim identified situations in which eustress may be observed, so that empirical findings can be interpreted meaningfully within those boundaries (Bonetto et al., 2023; Scheel et al., 2021). In the final aim, insights from the previous aims were combined to verify that challenging situations induce eustress, and to investigate how eustress and its underlying influential processes vary across individuals and situations. I note that the steps undertaken in this research are not exhaustive but hopefully contribute towards a robust and contextualized theory of eustress that can be tested, changed, and expanded systematically.

Whereas this thesis does not use experimental hypothesis testing, it incorporates confirmatory and exploratory statistical predictions about data distributions, quality of measurements, and non-causal relationships between variables. The scientific method and findings of this thesis were further influenced by technological advances, specifically artificial intelligence (AI), that I introduce below.

1.8.3 Use of Artificial Intelligence (AI)

Since the 1950s, research in AI has focused on simulating aspects of human intelligence that are traditionally studied by psychologists (e.g., reasoning, problem solving, and perception; Simon & Newell, 1971). Vice versa, advances in AI, such as machine learning, deep learning, and generative AI increasingly influence psychology and social sciences (Bartlett et al., 2023; Demszky et al., 2023; Korinek, 2023), further influencing societies and culture (Brinkmann et al., 2023; Rahwan et al., 2019). This section therefore introduces the AI tools that were used in the current research, whereas the general discussion provides a perspective on how the findings and data from this thesis may be used in AI applications.

This thesis applied unsupervised clustering for data exploration and large language models (LLMs) for item generation and evaluation. Unsupervised clustering is a machine learning method that offers a flexible statistical approach to group data points based on their similarities when data labels are unknown (J. Gao et al., 2020; Henninger et al., 2025). Because prior knowledge about eustress is limited, this thesis used unsupervised clustering to identify groups of individuals with similar eustress profiles (Aim 2) and situations with similar feature profiles (Aim 3).

This thesis further employed LLMs, transformer-based machine learning systems that are trained on enormous amounts of data to produce or analyze meaningful linguistic and multimodal information, including predicting human judgements (e.g., Abdurahman et al., 2024; Hewitt et al., 2025) or simulating study participants (Argyle et al., 2023; J. S. Park et al., 2024). This thesis used an LLM to generate candidate psychometric items and to predict human responses (Aim 3). The chosen LLM was open source to comply with open science principles of transparency, accessibility, and sharing (Hussain et al., 2024). I note that LLMs and AI research in general evolve rapidly so that the presented processes and supporting literature may be outdated by the time this thesis is completed.

1.8.4 Overview of empirical projects

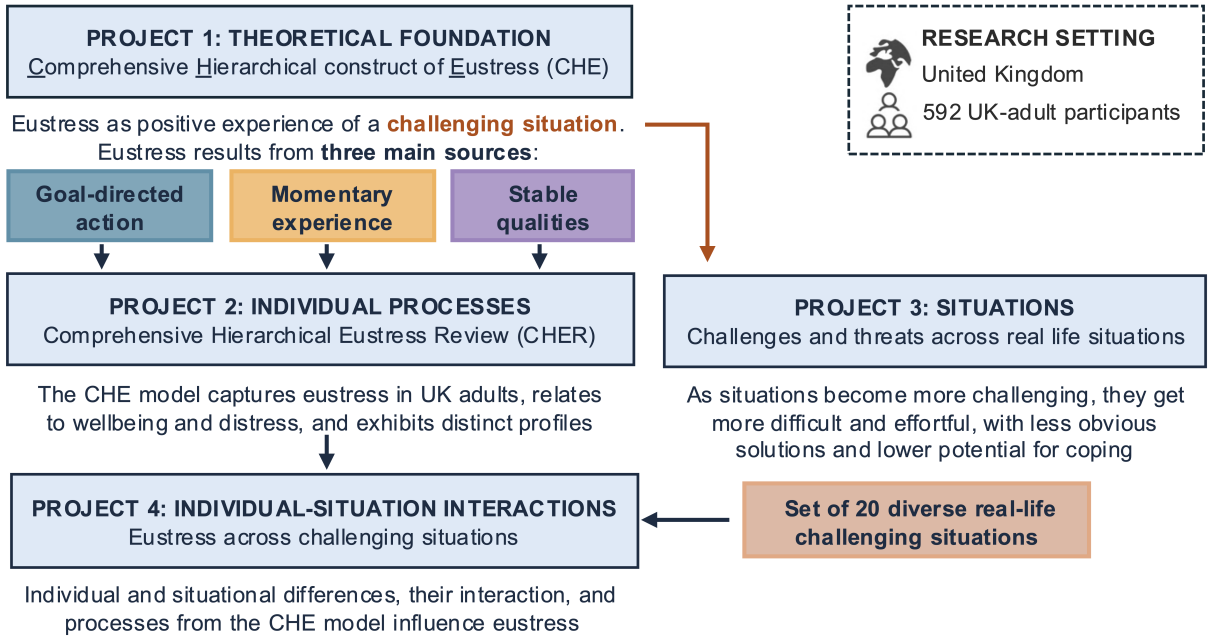
I conducted the following research to identify conceptualizations of eustress from published literatures and to understand how eustress manifests in UK adults in general and in specific real-life situations. Figure 1.2 illustrates links between the research projects within the overall framework of this thesis. I use the pronoun "we" instead of "I" during this section to acknowledge the contributions of the co-authors involved in these chapters.

In Project 2 (Chapter 3), we developed and assessed a novel eustress instrument. The Comprehensive Hierarchical Eustress Review (CHER) included 47 items across three subscales, reflecting CHE's structure. In a quantitative study ($N = 260$), we established features of our model that were central to experiencing eustress and the psychometric structure that best fits these features. We assessed how eustress relates to distress and

psychological wellbeing, and we identified groups of people who share similar eustress profiles. We aimed to test CHE and establish how UK adults experience eustress in general across challenging situations in their lives.

Figure 1.2

Overview of thesis projects



In Project 3 (Chapter 4), we conducted a preregistered study that identified and described challenging and threatening situations that likely provoke eustress. Using an open-source LLM, we developed 20 real-life difficult situations and asked 81 UK adults judge each situation in terms of threat, challenge and eight theory-derived features (e.g., intrinsic difficulty). We repeated the situation evaluation with an open-source LLM. We aimed to develop and evaluate a normed set of real-life situations that comprehensively represent threat, challenge, and their associated features in UK adults. We further aimed to assess whether LLMs could approximate human judgments and capture structural relationships among them.

Finally, in Project 4 (Chapter 5), we combined insights from the previous chapters to conduct a preregistered study that established a predictive profile of eustress and explored how these profiles varied across individuals and real-life situations. We conducted a quantitative survey ($N = 251$) to collect participants' self-reported eustress across various real-life situations that were generated by an LLM (extracted from Project 3). In these situations, we also collected participants' ratings of the potential influences of eustress (e.g., positive affect, engagement; extracted from Project 1 and tested in Project 2). We aimed to assess how varied eustress is across individuals and situations and how well previously

defined influences of eustress predict it across situations in real life.

We prepared Projects 1 – 4 as separate journal articles, so their content may overlap, especially in the Introduction sections of each chapter. Project 1 was published in *Current Psychology*. Project 2 was published in the *Journal of Happiness Studies*. Project 3 is available as a preprint. Project 4 is under review and available as a preprint.

Chapter 2

Establishing a Comprehensive Hierarchical construct of Eustress (CHE)

This chapter is an exact copy of the following publication:

Kloidt, J., & Barsalou, L. W. (2024). Establishing a Comprehensive Hierarchical construct of Eustress (CHE). *Current Psychology*, 43, 32258–32273. https://doi.org/10.1007/s12144-024-06750-7

The supplementary materials (SM) for this publication are openly accessible at: https://eprints.gla.ac.uk/336287/

We have uploaded the raw data and analysis files to the Open Science Framework. They can all be accessed here: https://osf.io/uf9dk/

2.1 Abstract

Eustress as a positive response to challenging situations has received increasing attention across diverse literatures, reflecting its potential to improve wellbeing, work performance, and personal growth. In the process, eustress has been defined, measured, and manipulated in myriad ways, leading to fragmentation and vagueness. Because a unified and well-specified construct would significantly support eustress research, we developed one here. Rather than basing it on our subjective views, we developed it empirically, extracting 57 unique features of eustress from 80 theoretical, interventional, empirical, and psychometric articles. Organizing and interpreting these 57 features produced a Comprehensive Hierarchical construct of Eustress (CHE). According to CHE, eustress emerges from three sources: (1) successful goal-directed action,(2) experiencing the moment in an enjoyable, fulfilling, or meaningful manner, and (3) positive stable qualities of the individual. Within each source, CHE establishes specific facets of eustress hierarchically, which in turn organize the 57 eustress features extracted initially. Bibliometric analyses identified CHE's hierarchical elements addressed most often in the eustress literatures. Overall, these results suggest that eustress cannot be specified with a simple definition but should instead be viewed as a family resemblance structure having statistical properties. Rather than taking a single form, eustress manifests itself as diverse states during successful goal-directed action and fulfilling momentary experience. Regularly producing eustress in these manners likely establishes CHE's trait-like qualities for generating eustress effectively on future occasions. Interestingly, these qualities overlap highly with well-established elements of wellbeing, suggesting that wellbeing contributes to eustress in challenging situations.

2.2 Introduction

The phenomenon of eustress—what we define here as a positive response to challenging situations—has received increasing interest across diverse areas. In the public sphere, wellness and lifestyle trends embrace positive thinking and effective coping as key strategies for tackling everyday challenges. In academia, multiple disciplines have increasingly explored eustress, including health psychology, positive psychology, occupational psychology, and educational psychology. From both perspectives, generating eustress in challenging situations has significant potential to enhance an individual's quality of life and wellbeing. By better understanding eustress and its relations to wellbeing, increasingly sophisticated tools for measuring and augmenting it in individuals can be developed.

2.2.1 Diversity of the eustress literature

When one begins reading the eustress literature, it is easy to become overwhelmed by the diverse forms that eustress takes in challenging situations, by the multitude of cognitive, affective, and behavioral processes associated with it, and by the many ways researchers study it. On the one hand, this state-of-affairs illustrates the rich multifaceted nature of eustress. On the other hand, relatively little unity exists in our understanding and assessment of eustress as a construct.

When investigating eustress, researchers sometimes focus on the situations where eustress occurs (e.g., what challenges are present?). Or sometimes researchers focus on the individuals experiencing eustress (e.g., how does the individual perceive and process challenges?). Or sometimes researchers focus on potential outcomes of experiencing eustress (e.g., what actions and consequences emerge from it?).

Even within a specific focus on situations, individuals, or outcomes, considerable variability on the research performed exists. Consider some examples. When researchers focus on challenging situations, some establish specific events as eustress-inducing (Cavanaugh et al., 2000), whereas others operationalize eustress as emerging from inter-personal interactions (Hargrove et al., 2015; Simmons & Nelson, 2007). When researchers focus on qualities of individuals, eustress is again characterized in different manners, such as a desirable cognitive state (Edwards & Cooper, 1988), a regulatory process (Crum et al., 2020), or as a positive emotion (Rudland et al., 2020). Finally, when researchers focus on outcomes, again, many possibilities emerge. Positive psychology and health psychology aim to improve individual mental health and wellbeing by providing individuals with skills that produce positive mental states (e.g., optimism; Aspinwall & Tedeschi, 2010). Occupational psychologists promote eustress to increase productivity, for instance, by inducing states of flow (Hargrove et al., 2015; Le Fevre et al., 2003). Educational psychologists promote eustress to increase learning, time management, and personal growth (Rudland

et al., 2020).

Although these differences may appear subtle, they can have considerable influence on how researchers conceptualize, measure, and foster eustress. When focusing only on challenging situations, researchers fail to recognize that individuals exhibit major differences in the trait-like qualities that contribute to eustress, and that situations and individuals dynamically influence one another bidirectionally (cf. Bandura, 1978; Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021). Conversely, focusing only on eustress as a trait-like quality in individuals fails to acknowledge the important contributions that challenging situations contribute. Finally, focusing only on the outcomes of eustress fails to establish an understanding of how interactions between individuals and challenging situations produce eustress outcomes jointly. Although it can be fascinating to explore the rich complex character of eustress, one can come away with a fragmented incoherent understanding of the construct and its applications.

2.2.2 History of eustress research

Difficulties in establishing a consensual definition of eustress date back to its initial formulations. The medical researcher, Hans Selye, provided a first milestone for eustress by defining stress as a general physiological reaction of varying intensity to a difficult situation (Stress-as-Adaptation-Syndrome; Selye, 1936, 1974). Depending on an individual's perception, cognition, and affect, this reaction could result in bodily adaptation, defined as *eustress*, or in maladaptation, defined as *distress*.

Moving beyond broad physiological patterns, the psychologists Richard Lazarus and Susan Folkman understood eustress as resulting from constructive cognitive appraisals of agent-environment interactions in difficult situations. Their Transactional Model of Stress proposed that individuals interpret relevant stressors (i.e., stress-evoking stimuli) in terms of meeting or exceeding available coping resources. Meeting available coping resources induces eustress, whereas exceeding these resources induces distress (Lazarus, 1966; Lazarus & Folkman, 1984; Lazarus & Folkman, 1987).

At first glance, these traditional stress models may appear very different. Whereas Selye's approach defines eustress as an adaptive bodily reaction, Lazarus and Folkman's approach characterizes eustress as a positive cognitive reappraisal of a difficult situation. Notably, however, these two approaches are not contradictory: There is plenty of room for a construct of eustress to simultaneously accommodate physiological responses to difficult situations and cognitive appraisals of them. Indeed, the stress literature often notes the ubiquitous presence of both in how organisms handle stress (Epel et al., 2018).

Subsequent accounts of eustress built on both early traditions. The Challenge-Hindrance Framework (Cavanaugh et al., 2000) and the Holistic Stress Model (Simmons & Nelson, 2007) offered two prominent second-generation accounts, with each developing from the

perspective of occupational psychology. Both integrated Selye's focus on varying stressor intensity in the body, together with Lazarus and Folkman's focus on appraisal-dependent response valence.

The Challenge-Hindrance Framework categorizes stressors into challenge stressors and hindrance stressors. Although both types of stressors may induce strain to an employee, challenge stressors are perceived as energizing opportunity for growth and accomplishment, whereas hindrance stressors are not (Cavanaugh et al., 2000). One potential problem with the Challenge-Hindrance Framework is that it postulates two different kinds of stressors, when in actuality, there may only be difficult situations and different ways of perceiving them, as in the classic distinction between threats and challenges (Blascovich et al., 2000).

The Holistic Stress Model extends the threat-challenge approach to eustress, proposing that stressors are inherently neutral, with their appraisal resulting in emotional, attitudinal, and behavioral responses that can be positive, not just negative. Positive responses (i.e., eustress) can include emotions such as joy and happiness, attitudes such as hope and meaningfulness, and behaviors such as forgiveness. The amount of eustress an individual experiences depends on their personal characteristics and their strategies for fostering positive states (Simmons & Nelson, 2007).

When directly comparing the Challenge-Hindrance Framework and the Holistic Stress Model, the latter offers a more nuanced construct of eustress. By defining situations as inherently neutral, the Holistic Stress Model acknowledges the importance of agent-environment interactions in difficult situations. Consistent with empirical findings, the Holistic Stress Model further allows for holding positive and negative appraisals simultaneously, thereby explaining complex intra-individual states. Notably, however, both the Holistic Stress Model and the Challenge-Hindrance Framework only address eustress in occupational settings and therefore do not offer a general account of eustress across situations and individuals. A broader construct of eustress would be useful.

2.2.3 Current state of eustress research

Despite promising attempts, the construct of eustress lacks a well-developed conceptualization. Current formulations primarily support specific projects and are not intended as a general account of eustress. As a consequence, diverse ways of thinking about eustress have developed, and no single construct has emerged that can cover different kinds of eustress research, much less integrate them. To illustrate this fragmentation, we next review the diverse forms that eustress takes in research that focuses on individual differences, challenging situations, and diverse outcomes. We propose that to fully appreciate and appropriately implement the insights in this work, a systematic integration of them is needed.

Individual differences

At the individual level, psychometric research demonstrates that individuals vary in the overall levels of eustress they experience across challenging situations—what might be referred to as *trait eustress* (e.g., O'Sullivan, 2011). Whereas some individuals experience eustress consistently in challenging situations, others only experience it occasionally, if at all.

When addressing how individuals perceive and foster eustress in challenging situations, existing research has tended to focus on populations that could benefit from increasing their eustress. For example, health and positive psychology interventions often address eustress in the wellbeing of healthcare providers and recipients (Bultas et al., 2021; Giordano et al., 2022). Occupational interventions often target eustress in the work performance of managers and employees (Cavanaugh et al., 2000). Educational interventions often foster eustress to improve the learning experiences of students and teachers (Duan & Bu, 2019; Hepburn et al., 2021; Rahm & Heise, 2019). Focusing on individuals with high eustress potential has contributed to understanding specific eustress phenomena in these specific populations. Perhaps, however, a general formulation could attempt to integrate these findings across different populations into a unified coherent construct.

Challenging situations

The experience of eustress varies extensively, not only across individuals, but also dynamically across challenging situations within an individual. What we will refer to as *state eustress* varies across challenging situations as an individual's goals, values, internal states, coping resources, and many other factors vary. This dynamic variability across situations within individuals complements stability in eustress between individuals.

Whole-Trait-Theory, for example, posits that individuals have control over the personal qualities they express in a given moment (Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021). As a consequence, when an individual realizes that they're in a challenging situation, they could try to produce a state of eustress in it. Perhaps they might view this situation as an opportunity to work towards their personal goals, or believe that engaging with this situation matches their core values, or simply feel energized to tackle this challenge. Alternatively, the individual might feel so overwhelmed by the situation that they only experience distress in it, rather than attempting to generate eustress.

When investigating situations where eustress occurs, researchers often focus on situations with a high potential for inducing eustress. For example, researchers have identified the workplace as a frequent source of challenges, including hospitals (Lin et al., 2019), universities (Duan & Bu, 2019), and corporations (Cavanaugh et al., 2000). Some researchers have further addressed how specific aspects of a workplace influence eustress, such as a team climate (Kozusznik et al., 2015).

Although these investigations deepen our understanding of workplace challenges, again little research has attempted to establish insights that cover different eustress situations broadly. We further note that little research has actually addressed dynamic variability in eustress across situations within an individual. Considering the current state-of-affairs, not much is known about how a general eustress trait manifests itself in specific challenging situations across an individual's psychological states over time.

Diverse outcomes

Reflecting on the diverse ways that eustress has been conceptualized as both a trait and a state, it's not surprising that eustress interventions take diverse forms and aim to achieve diverse outcomes. When mindfulness interventions are implemented, for example, they can take the form of an awareness prompt, a breathing exercise, or a yoga session (Lin et al., 2019; Montanari et al., 2019). When positive psychology interventions are implemented, they can take the form of reappraising a situation positively, producing gratitude, or reviewing one's strengths (Duan & Bu, 2019; Rahm & Heise, 2019). When resilience interventions are implemented, they can take the form of a positive coping strategy, experiencing connectedness with nature, or practicing optimism and self-confidence (Giordano et al., 2022).

Although eustress interventions often focus on a single strategy or outcome (e.g., Bultas et al., 2021), they can also combine multiple strategies and outcomes (e.g., Hepburn et al., 2021). Complex interventions have the advantage that they may better serve diverse populations of recipients across dynamically changing situations. As a complex intervention increasingly includes multiple strategies and increasingly aims at producing multiple outcomes, it becomes increasingly likely that at least one strategy will fit an individual in their current situation, achieving at least one desired outcome. In this manner, an effective eustress intervention could result from integrating the most effective strategies and the most likely outcomes within the space of eustress interventions.

2.2.4 Towards conceptual clarity

As we have seen, cross-disciplinary research has begun to establish the rich multidimensional character of eustress. Equally apparent, however, is the lack of integration. Conceptualizations of eustress are highly fragmented, not only across the diverse communities that work with eustress, but also within them. Significantly, though, how a construct like eustress is characterized influences its application in any domain. Conceptualizations of eustress, for example, determine how one performs research on eustress, including theory development, research design, and statistical analysis (Bringmann et al., 2022). Conceptualizations of eustress similarly determine how one measures eustress and

how one develops interventions to change it. For these reasons, fragmentation of the eustress construct undermines its scientific credibility and limits its effective application.

Like Le Fevre et al. (2003), we believe that integrating the fragmented eustress literature would significantly strengthen eustress research, making it more coherent and better coordinated within and between communities. Additionally, an integrated construct of eustress would support measuring it more accurately with psychometric instruments and laboratory research, along with motivating more effective behavior-change interventions for inducing eustress.

In this spirit, our primary aim here was to develop and articulate a comprehensive, well-integrated construct of the eustress that people generate in challenging situations. To do so, we conducted a scoping review of the eustress literatures, empirically extracted features of eustress addressed in it, and then organized these features into an integrated coherent construct of eustress. Rather than imposing our subjective views on what we believe is important about eustress, our theoretical approach synthesized, structured, and evaluated what the community of eustress researchers has previously determined is important about it.

As we will see, a hierarchical construct of eustress emerged that offers a clear, coherent, and compelling account of the sources that produce eustress in individuals. If we had tried to develop a construct of eustress subjectively, we doubt that it would have been as successful. As we will further see, this account has significant potential for informing the construction of future eustress theories, developing powerful new measurement tools, designing empirical studies that isolate eustress processes, and formulating behavior-change interventions capable of influencing these processes.

2.3 Methods

Using Dubin's (1976) deductive approach to theory building, we implemented a bottom-up empirical procedure to (1) establish phenomena associated with eustress in the literature, (2) systematically identify and retrieve relevant studies, (3) extract eustress features from these studies, (4) integrate these features into an initial theory through inferring their structure, and (5) empirically evaluate the resulting theoretical construct (Holton & Lowe, 2007). Following Dubin's deductive approach therefore allowed us to capitalize on previously established evidence-based features of eustress, while further synthesizing, structuring, and interpreting them from a theoretical perspective.

We established eustress phenomena through an initial review of the literature and then performed a scoping review that retrieved diverse articles on eustress from relevant scientific, clinical, and applied literatures. For each identified article, we extracted features of eustress that it posited theoretically, operationalized methodologically, measured empiri-

cally, and/or targeted in an intervention. Across articles, we organized these features into clusters (each with multiple facets), and then organized these multifaceted clusters into a hierarchical structure. To ensure that the inferred structure reflected the existing research rather than our perspectives, both authors examined and specified the extracted features carefully before developing the initial theory. This process resulted in the Comprehensive Hierarchical construct of Eustress (CHE). Finally, we performed bibliometric analyses to empirically evaluate the relative importance of the features, facets, and clusters, as reflected in different eustress literatures.

2.3.1 Literature search

We performed systematic literature searches up to May 2022. When performing a search, we first implemented Boolean operators for "eustress", "positive stress", and "challenge stress" in Web of Science. No temporal filter was applied for "eustress", but we restricted searches for "challenge stress" and "positive stress" to studies published since 2018 to capture emerging interest in these areas yet arrive at a relevant and manageable sample. To ensure that our search criteria did not exclude relevant work, we cross-searched the "eustress" Boolean operator in PubMed and examined the references of identified articles for additional articles.

To be included in our review, research articles had to: (1) assess eustress as a cognitive, affective, and/or behavioral process in humans, (2) present a theoretical model, a psychometric measure, an empirical study, or a behavior- change intervention, and (3) be available as full-text in English.

2.3.2 Extracting, integrating, and interpreting features

For each identified article, we first identified sections that described, discussed, and/or used eustress in some manner. We then extracted features of eustress that these sections posited theoretically, operationalized methodologically, measured empirically, and/or targeted in an intervention. Following the extraction process, we integrated features of eustress into a theoretical construct as follows. We eliminated duplicate mentions of a feature and organized unique features that were related into coherent clusters that we will refer to as *facets*. Each facet captured one aspect of the multifaceted eustress construct that emerged from the theory-building process. We used the most representative feature of each facet as its label (e.g., mindfulness, affect, resilience). For three facets, none of the features sufficiently covered all its associated features, so we developed new facet labels for them (i.e., environment, self-relevance, outcomes).

When examining facets established during the first phase of clustering, groups of facets appeared related. To capture this higher-level emergent structure, we then organized facets

hierarchically into a second level of clusters that we will refer to as *sources*, where a source is a process from which eustress originates. Resulting from our interpretation of these highest-level clusters, we identified three sources: (1) goal-directed action, (2) momentary experience, and (3) stable qualities of the individual.

2.3.3 Empirical evaluation

In a final step, we performed bibliometric analyses to establish the relative importance of the sources, facets, and features throughout the eustress literature in general, and also within particular eustress literatures more specifically. Using R (v4.3.2; R Core Team, 2023), we computed frequencies, proportions, and intraclass correlations for articles that exhibited various sources, facets, and features. Results from this bottom-up approach, at a minimum, establish the sources, facets, and features of eustress that have received the most and least attention across the eustress literatures.

2.4 Results

From 1,270 identified records, 80 articles published from 1974 to 2022 met the inclusion criteria for our scoping review. The final sample included articles broadly spanning the disciplines of health psychology ($n = 32$), industrial-organizational psychology ($n = 29$), and educational psychology ($n = 19$), illustrating the diversity of eustress in challenging situations. The included articles further represented diverse interventional ($n = 32$), theoretical ($n = 19$), empirical ($n = 17$), and psychometric ($n = 12$) research. The supplemental materials file, SM-1, presents the search process and provides references for all included articles.

From each article, we extracted all features related to eustress ($Mdn = 9$, range = 2 – 23 features per article) resulting in a total of 790 features extracted across 80 articles. The supplemental materials file SM-2 presents the extracted features from each included article, further providing information on the author(s), publication year, research field, and type of article. After extraction, we organized the 790 features of eustress into 57 unique features and counted duplicate mentions across articles. Table 2.1 presents the most frequent features of eustress that were mentioned in at least 20 out of 80 articles. Regardless of their frequency, all 57 unique features of eustress entered the theory building process to develop a comprehensive construct of eustress.

Table 2.1

The most common eustress features

Eustress feature	***n***	*%*
Benefitting from insightful appraisal and reasoning that supports effective goal pursuit	50	62.50
Effective skills / coping efficacy	34	42.50
Control / manageability	32	40.00
Achievement / accomplishment	29	36.25
Growth / personal development	28	35.00
Awareness of the internal and external environment	27	33.75
Presence of physical and social supporting resources	26	32.50
Experiencing good relationships (family, friends, colleagues, etc.)	26	32.50
Happiness / joy	22	27.50
Seeing potential to pursue a constructive goal / purpose / inspiration	21	26.25
Positive affect	20	25.00
Fully present attention / focus	20	25.00

Note. Eustress features extracted from at least 20 articles in descending order of mentioning count. The total number of unique features was 57, and the total number of included articles was 80. n is the number of articles mentioning the feature; % is the percentage of articles mentioning the feature

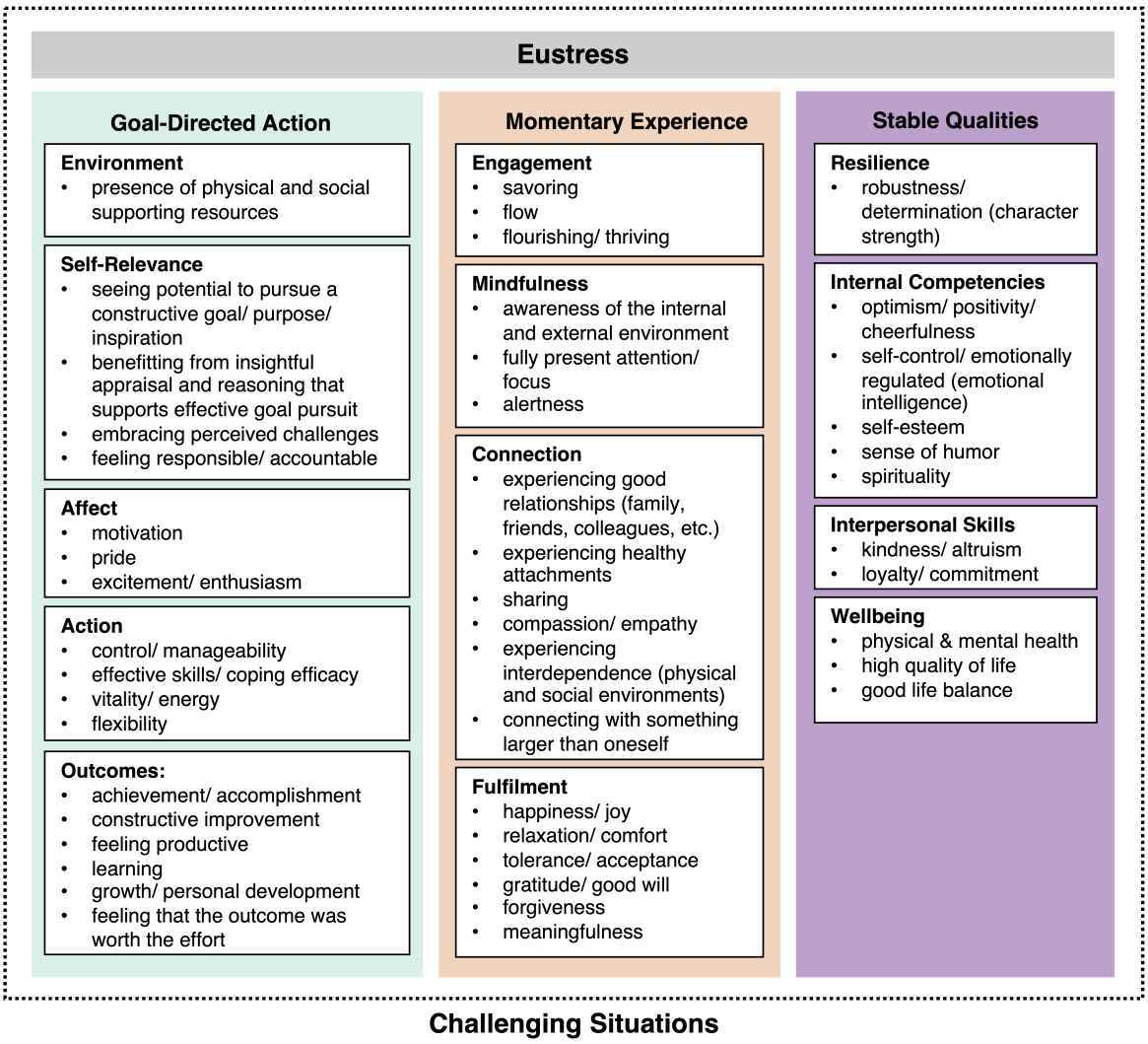
2.4.1 A Comprehensive Hierarchical construct of Eustress (CHE)

After removing duplicate mentions, we clustered the remaining 57 unique features of eustress into 13 coherent facets of eustress. For 10 of these facets, we used the most representative feature as its label (reducing the number of eustress features within facets to 47). For the remaining 3 facets, we inferred a representative label that covered its features conceptually (environment, self-relevance, and outcomes within the source of goal-directed action). In a second step, we organized the 13 facets into 3 high-level sources of eustress.

Figure 2.1 presents this hierarchical clustering of features at the two levels. At the most abstract level, feature clusters are organized into the three sources for goal-directed action, momentary experience, and stable qualities of the individual (illustrated in the columns of Figure 2.1). At the middle level of abstraction, Figure 2.1 organizes the features into 13 facets (the white boxes within each column). At the most detailed level, the 47 unique features of eustress that did not serve as facet labels are presented as bullet points within the facet boxes. We next describe each eustress source, together with its associated facets and features.

Figure 2.1

Comprehensive Hierarchical construct of Eustress (CHE)



Note. Each colored column depicts a source of eustress at the highest level of organization (bolded headers). Within each column, white boxes illustrate mid-level facets belonging to each eustress source (bolded box headers). Finally, each facet box contains associated low-level features of eustress extracted from the eustress literature (bullet points). Together, CHE's structure proposes 3 high-level sources, 13 mid-level facets, and 47 low-level features. We used the most representative feature within each facet as the label for 10 facets, and inferred a representative label that covered the relevant features within the 3 remaining facets of goal-directed action (environment, self-relevance, outcomes)

Goal-directed action

The source of goal-directed action encompassed 20 eustress features, organized into 5 facets, including the 2 facet labels for affect and action (the left column of Figure 2.1). As can be seen from examining these features, experiencing any one of them could po-

tentially contribute to an experience of eustress while performing goal-directed action in a challenging situation. Eustress, for example, could result from experiences of achievement, excitement, and efficacy while pursuing a goal. Together, these features establish goal-directed action as an important source of eustress. When achieving goals effectively, eustress is likely to develop through these features. For this reason, it is not surprising that many articles establish these features as important for experiencing eustress (see Figure SM-2.1 in the Supplemental Materials).

The five labels for facets of goal-directed action were inspired by the situated action cycle, which organizes goal-directed action into five phases: environment, self-relevance, affect, action, and outcomes (Barsalou, 2020; Dutriaux et al., 2023). Specifically, when environmental conditions and cues relevant to an agent occur, their self-relevance with respect to the agent's goals, values, identity, and norms is established. In turn, appraisals of self-relevance induce affective states, often in the agent's body, associated with emotion and motivation. These affective states initiate diverse forms of action, from eye movements to overt behaviors, that produce outcomes in the body and environment. Once the cycle completes, it may iterate as current goal-directed action persists, or when a new goal-directed action replaces it, responding to new environmental conditions. Every time the cycle runs, it establishes learning, conditioning, and memory via a variety of learning and reward circuits in the brain. As Barsalou (2020) describes, this basic organization of action has been proposed for decades in behaviorism, computer science, psychology, and neuroscience.

The left column in Figure 2.1 illustrates how 20 features of eustress form clusters that are related to the 5 phases of the situated action cycle. As can be seen, some facets are relatively simple, focusing on one or a few features, whereas other facets are relatively complex, containing a range of related features.

Momentary experience

The source of momentary experience encompassed 22 eustress features, organized into 4 facets for engagement, mindfulness, fulfilment, and connection, including the 4 facet labels (the middle column of Figure 2.1). In contrast to how the facets of goal-directed action were originally grounded in a cognitive process model (the situated action cycle), the facets for momentary experience were first established empirically, reflecting the most representative feature for each cluster.

We hasten to add that, retrospectively, we noticed the similarity of these facets to four factors in the PERMA theory of human flourishing: positive emotion, engagement, positive relationships, and meaning (Seligman, 2012). Notably, the facets of momentary experience here differ from the PERMA factors as they only bear on challenging situations, not on situations more generally. Nevertheless, the facets of our second source–like those of

our first source–are closely related to a pre-existing theoretical framework. Also similar to the facets for goal-directed action, the facets observed for momentary experience contained different numbers of features, with fulfilment and connection being more complex (i.e., six features each) than engagement and mindfulness (i.e., three features each).

As the features for momentary experience suggest, eustress can result in the absence of pursuing goals, simply by engaging with challenging situations in the moment fulfillingly. Features such as savoring, awareness, connecting, and acceptance offer examples of how eustress can result through simple non-directed engagement. Together, these features establish momentary engagement as an important source of eustress. When engaging with the moment fulfillingly, eustress is likely to develop through these features. For this reason, it is not surprising that many articles on eustress establish these features as important for working with challenging situations effectively (Figure SM-2.2).

It is worth noting how achieving eustress via goal-directed action and momentary engagement complement each other. Eustress can be achieved either by focusing on goal-achievement or by letting go of goal-pursuit and simply engaging with a challenging situation in a pleasurable or meaningful way. We further assume, however, that eustress can also result from simultaneously engaging with the moment fulfillingly during goal pursuit.

Stable qualities

Lastly, the source for stable qualities of the individual encompassed 15 eustress features, organized into 4 facets for internal competencies, resilience, interpersonal skills, and wellbeing, including the 4 facet labels (the right column of Figure 2.1). Selection of the four labels for this source's facets were motivated by Lazarus and Folkman's (1987) systems approach to emotion regulation. In their framework, *internal competencies*, when enacted, provide a source of eustress; *resilience* and *interpersonal skills* modulate the enactment of these competencies; *wellbeing* is a possible outcome of enacting these competencies effectively. Whereas the facet for internal competencies synthesizes a complex set of features, the facets for resilience, interpersonal skills, and wellbeing contain fewer features.

As the features for stable qualities suggest, generating eustress in a challenging situation can be associated with well-established qualities of the individual. Features such as character strength, kindness, optimism, and good life balance offer examples of how eustress could potentially result through stable qualities (and strengthen them in turn). Together, these features establish an individual's qualities as an important source of eustress in challenging situations. When an individual develops these qualities, eustress is likely to result from having them. For this reason, it is not surprising that many articles on eustress establish these features as important (Figure SM-2.3).

It is worth noting how stable qualities contrast with goal-directed action and momentary engagement. Whereas stable qualities capture trait-level qualities of an individual,

goal-directed action and momentary engagement capture state-level experience (cf. Fleeson & Jayawickreme, 2021). It follows that eustress originates in both the traits of an individual and in the states they experience while pursuing goals and engaging with the moment. We address potential relations between eustress states and traits later in the discussion. We will also later address relations of these traits to the construct of wellbeing.

2.4.2 Bibliometric analyses of features, facets, and sources in CHE

Although CHE's structure in Figure 2.1 offers a comprehensive evidence-based construct of eustress, it does not specify the eustress sources, facets, or features most salient in the eustress literatures. Because CHE was derived from the process of deductive theory building, however, its understanding can be further informed by quantitatively evaluating the literature that contributed to it. In this spirit, we next establish the sources and facets in CHE that have received the most attention in previous work.

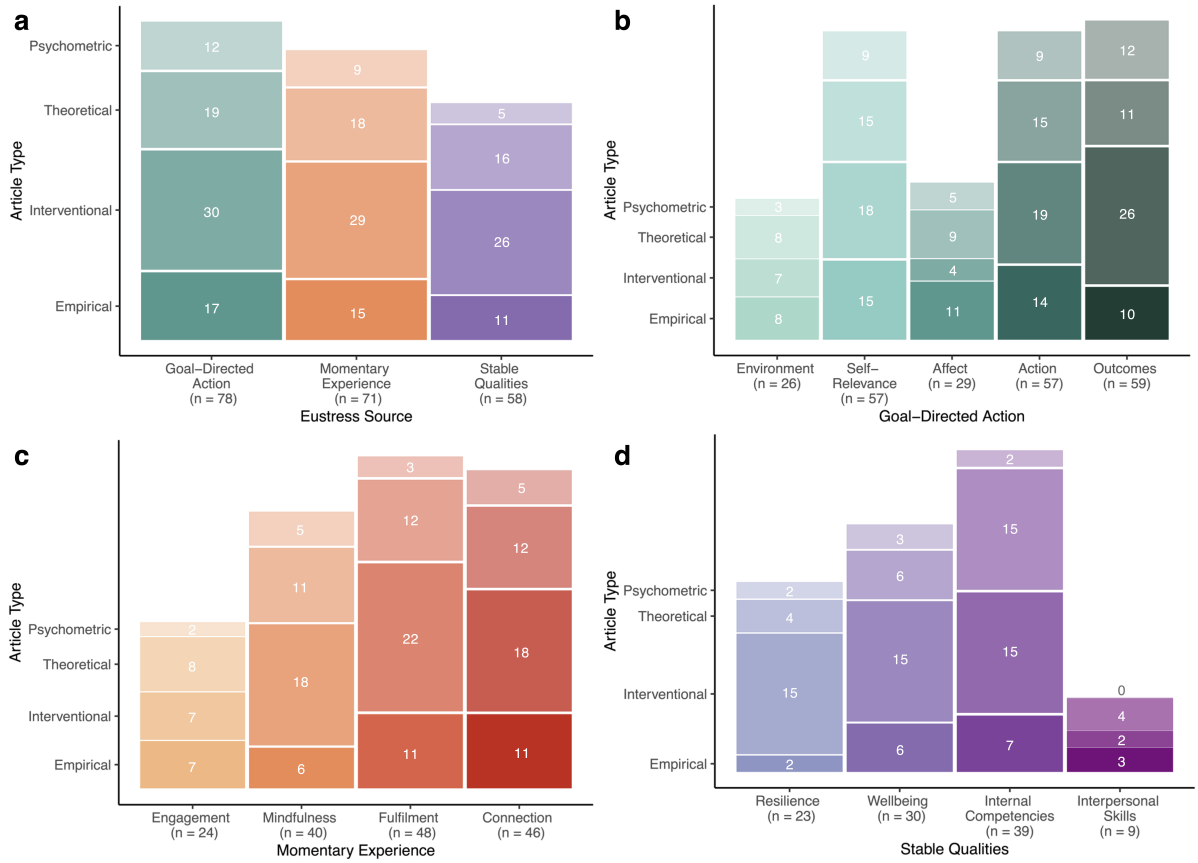
Before addressing this issue, we briefly mention two preliminary issues. First, eustress sources in CHE vary in their number of facets, and facets vary in their number of features. One possibility is that larger sources and facets in CHE have received more attention in the literature than smaller sources and facets, and have therefore been addressed by more articles. Although this may be true, it may not. How often the literature has addressed a specific source or facet may be unrelated to its size in CHE (i.e., its number of features). The following analyses assess this issue.

Second, how frequently a source or facet has been addressed could be relatively constant across interventional, theoretical, empirical, and psychometric articles. Alternatively, the frequency of a source or facet could vary widely from one literature to another. Again, the following analyses address this issue.

In the bibliometric analyses that follow, we identified the number of articles that mentioned each high-level source of eustress (i.e., a feature and/or facet belonging to the source) and the number of articles that mentioned each facet (i.e., a feature belonging to the facet and/or facet label). We present our quantitative analyses as stacked bar charts (Figure 2.2). Each chart depicts eustress sources (or facets) on the x-axis and article types on the y-axis. The overall height of a bar indicates how frequently the respective eustress source (or facet) has been mentioned across all four article types–psychometric, theoretical, interventional, and empirical. Within each bar, each of the four stacked cells for the four article types indicates how frequently a given type has been mentioned for each eustress source (or facet).

Figure 2.2

Stacked bar charts depicting mentions of eustress sources and facets by article type



Note. Number of mentions across article types for (a) high-level eustress sources, (b) goal-directed action, (c) momentary experience, and (d) stable qualities of the individual. The height of each bar illustrates the number of mentions for each source or facet (denoted in parentheses) across article types. Cell counts within a bar depict the number of mentions for specific article types

What sources in CHE are most common?

Nearly all the included articles on eustress included at least one feature and/or facet from the high-level source of goal- directed action ($n = 78$), followed by momentary experiences ($n = 71$) and stable qualities of the individual ($n = 51$; Figure 2.2a). This rank order of source frequency reflects the observed structural differences in CHE (Figure 2.1), where the number of facets is highest for goal-directed action, followed by momentary experiences and individual qualities. Conceptual differentiation of a source (as represented by facets) has therefore been accompanied by an increased frequency of attention (as represented by articles).

Cell counts in Figure 2.2a illustrate that interventional, theoretical, empirical, and psychometric articles exhibited the same rank order across the three eustress sources. To systematically assess the rank order of article types across eustress sources, we used the intra-class correlation (*ICC3* in Shrout & Fleiss, 1979). The *ICC3* establishes interrater

agreement between the fixed set of article types across sources. Values of the *ICC3* range from 0 to 1, with higher values indicating higher levels of agreement. Consistent with Figure 2.2a, interrater agreement between the four article types was high, with the *ICC3* being .88, indicating that the relative frequency of eustress article types was relatively constant across eustress sources.

What facets in each source are most common?

Goal-directed action. Within the source of goal-directed action, Figure 2.2b shows that the most frequently mentioned facets of eustress concerned outcomes ($n = 59$), self-relevance ($n = 57$), and action ($n = 57$), relative to the less mentioned facets of affect ($n = 29$) and environment ($n = 26$). The most mentioned facets – outcomes, self-relevance, and action – also contained the most unique features (i.e., 6, 4, and 5 features, respectively; Figure 2.1). The observed differences in conceptual importance (as reflected in the number of unique features) therefore reflected differences in frequency of mentions. As a facet became more important conceptually, it exhibited more features, and these features were addressed more frequently in the literature. Although the facets of affect and environment were mentioned least often, they were nevertheless mentioned quite frequently (i.e., 29 and 26 times, respectively), indicating that they have also been conceptually important.

Although included studies emphasized the importance of outcomes, self-relevance, and action, row-wise comparisons of the cell counts in Figure 2.2b illustrate differences in facet rank order by article type. Interventional and psychometric articles most frequently mentioned outcome features; empirical studies most frequently mentioned self-relevance features; theoretical models most frequently mentioned self-relevance and action features. These differences manifested as moderate interrater agreement between article types across facets, *ICC3* = .48. Thus, the four article types have focused on different facets of goal-directed action.

Momentary experience. Within the source of momentary experience, Figure 2.2c shows that the most frequently mentioned facets of eustress concerned fulfilment ($n = 48$), followed closely by connection ($n = 46$), mindfulness ($n = 40$), and then engagement ($n = 24$). Two of the most frequently mentioned facets—fulfilment and connection–each contained 7 associated features including the label names (Figure 2.1). For these facets, frequency of mention was related to frequency of unique features. This association further extended to the least frequently mentioned facet—engagement—which only had 4 associated features, exhibiting a conceptually simpler focus. In contrast, the facet of mindfulness was mentioned frequently but only had 4 unique features. Mindfulness appears to have been an important facet for momentary experiences in the eustress literatures, regardless of its small number of unique features.

Similar to the facets of goal-directed action, row-wise comparisons of the cell counts in Figure 2.2c depict differences in rank order for article types across facets of momentary experiences. Whereas interventional, theoretical, and empirical articles agreed on fulfilment as the most important facet for the source of momentary experience, this first rank was shared with the facet of connection for the latter two article types. For psychometric articles, the most commonly mentioned features belonged to the facets of mindfulness and connection, followed by fulfilment. Again, the observed differences between article types across facets manifested in moderate agreement, $ICC3 = .39$.

Stable qualities. Within the source of stable qualities, Figure 2.2d shows that the most frequently mentioned facets of eustress concerned internal competencies ($n = 39$), followed by wellbeing ($n = 30$), resilience, ($n = 23$), and interpersonal skills ($n = 9$). In addition to being most frequently mentioned, the facet of internal competencies contained the most unique features, reflecting a complex conceptual cluster (Figure 2.1). In contrast, the less frequently mentioned facets of wellbeing, interpersonal skills, and resilience exhibited conceptually simpler foci (i.e., 4, 3, and 2 feature(s), respectively). Except for the facet of internal competencies, the existing literature has placed relatively little emphasis on stable qualities relative to the other eustress sources. Of course, this pattern in the literature may well underestimate the importance of these qualities in eustress phenomena, a topic addressed in more detail later.

Row-wise comparisons of the cell counts in Figure 2.2d illustrate differences in the rank order of article types across facets. Interventional, theoretical, and empirical articles most frequently mentioned features related to internal competencies, although, for interventions, internal competencies shared the first rank with resilience and wellbeing. Compared to goal-directed action and momentary experience, observed differences between article types exhibited still lower interrater agreement for stable qualities, $ICC3 = .36$. Differences in frequency of mention across the four article types was greatest for this eustress source.

2.5 Discussion

The Comprehensive Hierarchical construct of Eustress (CHE) proposes that generating eustress in challenging situations originates from three sources: (1) successful goal-directed action, (2) experiencing the moment in an enjoyable, fulfilling, or meaningful manner, and (3) positive stable qualities of the individual. Each source further contains facets that integrate features for how individuals generate, experience, and embody eustress.

Unlike other eustress models, we derived CHE by combining a scoping review with an inductive approach to theory building that synthesized and structured a variety of different article types across the eustress literatures. Rather than only imposing our subjective

views on a construct of eustress, we instead collected and evaluated what the community of eustress researchers had previously determined as central to understanding eustress across a diverse collection of research areas. As a result, CHE's three-level hierarchical structure offers a comprehensive account of eustress.

The next three sections summarize how CHE addresses previously identified shortcomings of the eustress literatures: (1) fragmented conceptualizations of eustress, (2) lack of conceptual clarity (3), distinguishing between states and traits of eustress.

2.5.1 Integrating fragmented conceptualizations of eustress into a unified construct

Earlier we reviewed the diverse ways that researchers and practitioners have studied, measured, induced, and conceptualized eustress in challenging situations. CHE offers the first attempt to integrate these conceptualizations into a general account. At the highest level, CHE synthesizes diverse eustress features into the general sources of goal-directed action, momentary experience, and stable qualities of the individual. Hierarchically, at the next level down, CHE integrates insights from the domains of health psychology, industrial-occupational psychology, and educational psychology into facets and features that characterize the three top-level sources. Notably, diverse types of research inform this account, such that it integrates existing efforts from many researchers, practitioners, and disciplines.

2.5.2 Establishing conceptual clarity

The construct of stress has sometimes been criticized as too ambiguous and inadequate for effective use in research and intervention (cf. Kagan, 2016). As described earlier in the introduction, the more specific construct of eustress similarly suffers from fragmentation and lack of clarity across the diverse research communities where it has been addressed. Here, combining a scoping review with inductive theory building, we attempted to establish a clear, unified, and well-defined account of eustress.

Specifically, we established three general sources of eustress, each having specific facets that constitute its underlying structure (Figure 2.1). These facets offer a mid-level account of a multifaceted eustress construct that lie between abstract sources and specific features, thereby capturing important conceptual structure about eustress that is not too general nor too specific (analogous to basic level categories in natural taxonomies; Rosch & Mervis, 1975). Including this mid-level structure sharpens the eustress construct significantly in ways that can potentially contribute to understanding, measuring, and inducing eustress.

Using bibliometric analyses, we further investigated the facets of CHE that have received most attention in the eustress literatures, thereby establishing their relative im-

portance. For the source of goal-directed action, the most frequently mentioned eustress facets were successful outcomes, high self-relevance, and confident action (Figure 2.2b). For the source of momentary experience, the most frequently mentioned facets were feeling fulfilled, cherishing connections, and being mindful (Figure 2.2c). For the source of stable individual qualities, the most frequently mentioned facets were internal competencies, wellbeing, and resilience (Figure 2.2d). According to the existing literature, all these facets are central to the concept of eustress.

2.5.3 The importance of eustress states relative to eustress traits

CHE's lowest-level structure establishes specific features that are associated with both traits and states of eustress in challenging situations. Again, consider the 57 unique features of eustress extracted from the literature in Figure 2.1. As can be seen, 15 of these features have been organized into facets that underlie stable individual qualities (i.e., traits). Notably, however, 42 other features (i.e., nearly three times as many) have been organized into facets belonging to the state-oriented sources of goal-directed action and momentary experience. The considerable number of distinct features associated with eustress states clearly highlights their importance over trait-like qualities when investigating eustress. These features also offer many candidate items for empirical investigation into individual and situational variability in eustress states.

2.5.4 Eustress as a family resemblance construct

As we have seen, when someone finds themselves in a challenging situation, eustress can emerge from (1) performing goal-directed action successfully (2), experiencing the moment in an enjoyable, fulfilling, or meaningful manner, and/or (3) having positive stable trait-level qualities. Additionally, eustress can emerge from different facets or features within one of these sources, or from diverse combinations of several facets or features. It follows that eustress does not take a single form but instead takes myriad forms.

It further follows that eustress cannot be specified with a simple definition of facets and/or features that are present every time eustress is experienced. Instead, it makes more sense to view eustress as a classic family resemblance construct, where states of eustress do not necessarily share *defining* facets and features but instead are simply *similar* to each other, partially overlapping in the facets and features they exhibit in a given situation (Rosch & Mervis, 1975). Researchers have arrived at similar conclusions for many other constructs, including habitualness (Dutriaux et al., 2023), automaticity (Moors & De Houwer, 2006), impulsiveness (Sharma et al., 2014), and executive processing (Miyake et al., 2000).

As a consequence, the eustress construct has a statistical character, with frequent

facets and features being prototypical, and with less frequent facets and features being atypical. Figure 2.2a through 2.2d (along with Figures SM-2.1, SM-2.2, and SM-2.3) indicate the facets and features that are prototypical of eustress in the eustress literatures, while simultaneously capturing less likely facets and features that occur occasionally. From examining these figures, one can appreciate the many forms that eustress takes as its facets and features combine in myriad ways.

2.5.5 Implications for the nature of eustress

CHE's high-level sources offer a novel and compelling perspective on how individuals generate and maintain eustress. In challenging situations, eustress generally appears to arise in two fundamental ways that complement each other. Eustress can result from successful goal-directed action, including experiences of achievement, excitement, and efficacy while pursuing a goal. Or eustress can result in the absence of goal-pursuit (or together with it) from fulfilling momentary engagement, including experiences of savoring, awareness, connecting, and acceptance.

Notably, the specific form that eustress takes in a given moment likely reflects properties of the individual, the situation, and their interaction, together generating diverse *states* of eustress that exhibit a family resemblance structure (cf. Bandura, 1978; Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021; Mischel & Shoda, 1995). As individuals become skilled at achieving eustress habitually in either or both ways, stable qualities (traits) are likely to develop and become entrenched in the brain and the body through learning. As these stable qualities develop, they in turn support the production of eustress states during goal-directed action and/or momentary engagement.

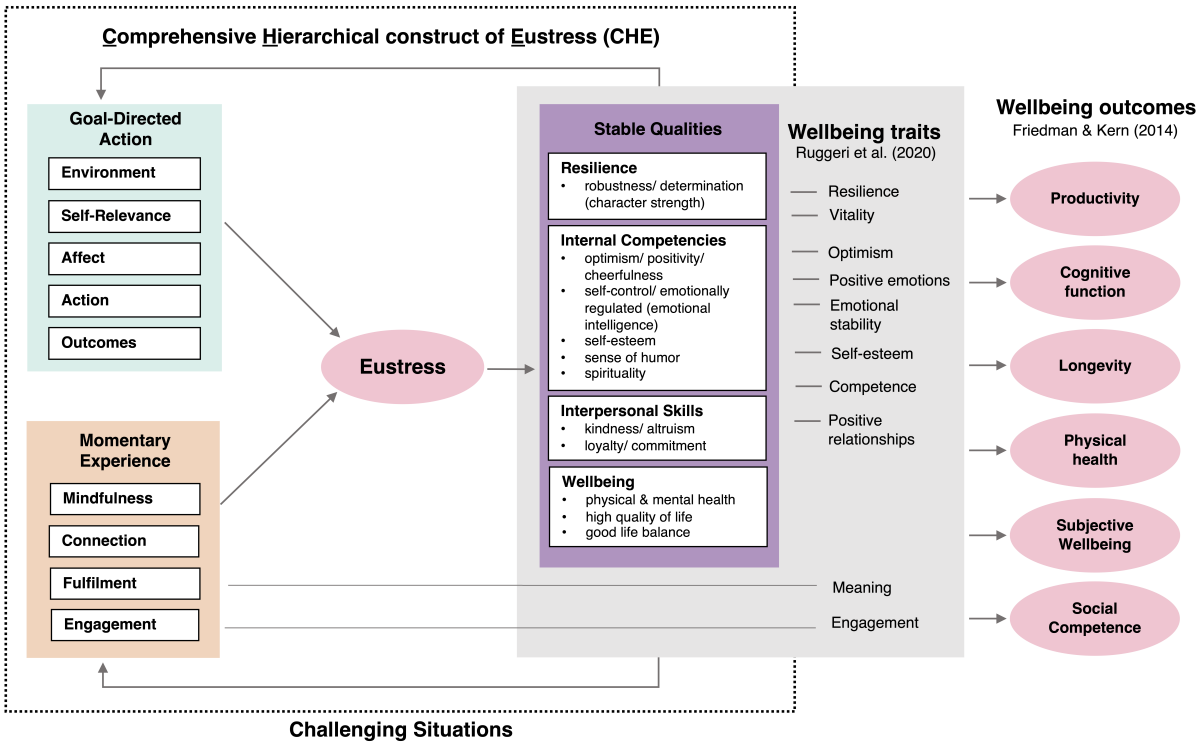
This account raises a variety of issues that future research could explore. First, are some individuals good at generating eustress only through goal-directed action or only through momentary experience; are other individuals good at generating eustress through both; are still other individuals good at neither? Second, as CHE's stable qualities associated with eustress increase across individuals, does the likelihood of generating eustress in challenging situations increase during goal-directed action and/or momentary experience? Third, and conversely, as successful goal-achievement and/or fulfilling momentary experience occur increasingly for an individual, do they increasingly establish the stable qualities associated with eustress in CHE? The literature on habits is likely to be useful for informing this issue. Following Dutriaux et al. (2023), along with much other literature they cite, rewards and outcomes are likely to play central roles in developing new eustress habits.

2.5.6 The relation of eustress to wellbeing

Interestingly, the stable qualities associated with eustress are closely related to traits associated with wellbeing. As Figure 2.3 illustrates, substantial overlap exists between facets of stable qualities in CHE and traits of wellbeing that an influential article by Ruggeri et al. (2020) established across cultures. As can be seen, eight of the ten traits that Ruggeri et al. established as central for wellbeing have counterparts in the CHE's stable qualities (vitality, resilience, competence, optimism, emotional stability, self-esteem, positive relationships, and positive emotions). The two remaining traits in Ruggeri et al., meaning and engagement, have counterparts in two of CHE's facets for momentary experience. These latter connections suggest that traits of wellbeing can manifest themselves as dynamic *states* when people generate eustress in challenging situations.

Figure 2.3

The relation of eustress to wellbeing



Note. CHE's construct of eustress appears on the left, with postulated causal paths between eustress and its sources. For goal-directed action and momentary experience, only their mid-level facets are shown (see Figure 2.1 for the specific features of each facet). For CHE's stable qualities, all 15 features and labels are shown so that they can be aligned with Ruggeri et al.'s (2020) 9 traits of wellbeing. Outcomes of wellbeing from Friedman and Kern (2014) are also shown on the right to illustrate that, unlike eustress, they are often likely to occur in non-challenging situations. See the text for further discussion

The strong overlap of CHE's stable qualities with traits of wellbeing might suggest

that eustress and wellbeing are essentially the same construct. Importantly, however, they clearly are not. Whereas eustress focuses on states that emerge while people attempt to handle challenging situations effectively, wellbeing covers a much broader range of situations that typically are not challenging. Consider the outcomes that occur when people experience high levels of wellbeing, as documented in Friedman and Kern's (2014) review of wellbeing. As Figure 2.3 illustrates on the right, these well-established outcomes include physical health, longevity, cognitive function, productivity, social competence, and subjective wellbeing. For the most part, these outcomes of wellbeing are not restricted to challenging situations and indeed may often primarily occur in non-challenging situations.

Notably, eustress was not directly included in Friedman and Kern's (2014) outcomes of wellbeing (although their productivity outcome is related to the importance of goal-directed action in CHE). Nevertheless, the high overlap between CHE's stable qualities and Ruggeri et al.'s (2020) traits of wellbeing suggests that eustress is likely to be another significant outcome of wellbeing: To the extent that an individual is high in wellbeing, they are likely to generate eustress in challenging situations. Conversely, to the extent that an individual tends to generate eustress in challenging situations, they are likely to increase their wellbeing.

2.5.7 Limitations

Passive empiricism

By employing a bottom-up theory-building approach, CHE recognizes and benefits from the rich and diverse eustress literature, using it to develop a comprehensive construct of eustress empirically. Data-driven constructs like CHE, however, can be criticized as passively producing a collection of existing features that suffers from a lack of reflective analysis and integrative synthesis—what has been referred to as the theorist's paradox (Holton & Lowe, 2007).

As described earlier, we addressed this issue as follows. After extracting evidence-based eustress features from the literature, we interpreted them conceptually by organizing them into mid-level facets and high-level sources that reflect widely-adopted theoretical models. Specifically, the facets of goal-directed action reflect the five phases of the situated action cycle (Barsalou, 2020; Dutriaux et al., 2023), and the facets of stable qualities reflect a systems approach to emotion (Lazarus & Folkman, 1987). Although the facets for momentary experience were developed in a data-driven manner, they parallel four of the five factors in the PERMA model (Seligman, 2012). As a consequence, CHE's construct of eustress reflects both empirical and theoretical influences.

Dependence on existing literature

A second line of criticism argues that the scientific value of a bottom-up theory depends on the comprehensiveness and quality of the evidence used to induce it. Because CHE is grounded in the existing eustress literature, the quality of its structure depends on whether its 57 empirically-based features cover eustress phenomena adequately. To the extent that previous eustress work is limited or biased, CHE's hierarchical structure and content are likely to reflect these limitations as well. Although we do not see any obvious omissions or commissions, we welcome suggestions that would strengthen CHE's structure and content. As research on eustress continues to evolve, the relevant structure and content of the eustress construct is likely to evolve as well.

Another related issue is that foci in the previous eustress literatures may have biased CHE's structure and content. Because, for example, the largest amount of research on eustress has been interventional, the resulting structure and content in CHE may have been biased towards behavior-change applications and their outcomes. One potential consequence, consistent with our quantitative analyses, is that CHE has therefore been influenced more by state experiences of eustress (149 mentions across articles) than by traits associated with eustress (58 mentions across articles; see Figure 2.2a for details).

Overall, CHE appears to provide a well-informed and well-integrated starting point for the continued development of a eustress construct. Although we cannot rule out potential bias in our theory, CHE synthesizes evidence-based features that have become well-established in the eustress literature implicitly for decades and that show substantial overlap with the adjacent research domain of wellbeing.

A cognitive-affective-behavioral focus

As described earlier, we restricted our literature search to articles that addressed cognitive, affective, and/or behavioral conceptualizations of eustress. Although the concept of eustress has received the most attention in psychological research, it has also been investigated in other disciplines. Perhaps most notably, medical research attempts to identify physiological patterns of eustress that contrast with its more prominently investigated counterpart of distress. And indeed, some research suggests that eustress exhibits a unique physiological fingerprint (Streamer et al., 2017). Notably, however, other research questions the claim that positive stress exhibits unique patterns of peripheral physiology (Bienertova-Vasku et al., 2020).

We do not aim to settle this debate. Nevertheless, it is important to bear in mind that CHE omits additional potential sources of features about eustress. Not only is CHE likely to benefit from including biological features, it is also likely to benefit from including cultural features at the system level (Craig et al., 2018).

2.5.8 Directions for future research

CHE offers a first attempt to provide a comprehensive account of eustress that integrates and interprets the existing literature. Yet, much remains to advance the understanding of eustress and its implications for assessment, research, and interventions.

First and foremost, we recommend validating CHE through further assessment. One intuitive strategy is to develop a psychometric instrument that assesses eustress across all three of CHE's top-level sources, further addressing the facets and features nested within them. Psychometric assessment could establish whether the most commonly mentioned sources, facets, and features across the literature are also the most important sources of eustress when assessed in a broad range of individuals.

A second step of validation could use a CHE-based psychometric instrument to test the proposed pathways between CHE's high-level sources. Specifically, such work could establish whether individuals need to be skilled at both goal-directed action and momentary experience to generate eustress, whether goal-directed action and momentary experience are necessary prerequisites for stable qualities, and whether stable qualities result from habitual success during goal pursuit and/or momentary engagement. Conversely, future research could assess whether having stable qualities associated with eustress increases the likelihood of generating eustress in challenging situations via successful goal-directed action and/or fulfilling momentary engagement.

A related direction for future research is to explore the relationship between eustress and wellbeing. For example,does wellbeing in non-challenging situations have a positive influence on eustress in challenging situations, and vice versa? Why is the overlap in stable qualities between wellbeing and eustress so high, and what are the implications for understanding wellbeing and eustress and for developing interventions to increase them?

Another important direction for eustress research is to examine the role of situations in eustress. A long tradition of research demonstrates compellingly that situations often explain more variance than traits in constructs such as extraversion and conscientiousness, together with large individual by situation interactions (e.g., Bandura, 1978; Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021; Mischel & Shoda, 1995). No doubt situations have an equally strong impact on eustress as they interact with individual qualities. For this reason, evaluating eustress in situations where it occurs is an important direction for future research, perhaps using approaches such as the Situated Assessment Method (Dutriaux et al., 2023).

Additionally, to expand CHE's scope beyond cognitive, affective, and behavioral research, it is important to search for physiological markers and other physical outcomes of eustress, including eustress-related behaviors. Physiological markers could include increased heart rate and ventricular contractility (Streamer et al., 2017), along with heart-rate variability, immune response, and telomeres (Epel et al., 2018). Physical outcomes

could include physician visits, social activity, and personal achievement. It would further be interesting to investigate cultural views of eustress, cultural structures that support or undermine eustress, and potential sub-populations who tend to experience eustress in either high or low amounts.

Overall, much opportunity exists for contributing to eustress research and applications. With our attempt to establish a comprehensive, unified, and clear construct of eustress, we hope to initiate the development of further eustress theories, measurement tools, empirical studies, and behavior-change interventions, ultimately advancing this important and promising field of research.

Chapter 3

Developing and evaluating the Comprehensive Hierarchical Eustress Review (CHER)

This chapter is an exact copy of the following publication:

Kloidt, J., & Barsalou, L. W. (2026). Developing and evaluating the Comprehensive Hierarchical Eustress Review (CHER). *Journal of Happiness Studies*, *27*(2), 28. https://doi.org/10.1007/s10902-025-00999-w

We have uploaded supplemental materials to the Open Science Framework including raw data, analysis files, and supplemental results files. They can all be accessed here: https://osf.io/s7mgy/

3.1 Abstract

Psychometric research on eustress—the positive experience of a challenging situation—faces a variety of issues that include: What features of eustress are central to experiencing challenging situations positively? What psychometric structure best fits these features (unidimensional, multidimensional, bifactor)? How is eustress related to distress and wellbeing? Can individuals be clustered effectively into different eustress profiles? To address these issues, we developed a novel eustress instrument: the Comprehensive Hierarchical Eustress Review (CHER), motivated by a new model, the Comprehensive Hierarchical construct of Eustress (CHE). Analogous to the CHE model, the CHER instrument contains three subscales for CHE's three sources of eustress (goal-directed action, momentary experience, stable qualities) with 47 items that reflect the 47 features of eustress that CHE extracted from the literature. To evaluate CHER and explore its potential for understanding eustress, we assessed it in a well-powered adult UK sample ($N = 260$). Using confirmatory factor analyses, we found that eustress is best understood as both a unidimensional and a multidimensional construct (i.e., a bifactor model), with items from all three subscales contributing to its conceptual core. The best performing model exhibited desirable internal qualities (satisfactory reliability and item discrimination) and external qualities (eustress negatively related to distress and positively related to wellbeing). Using latent profile analysis, we identified four clusters of individuals with different eustress profiles, who differed further on sociodemographic characteristics and personality traits. Findings reported have theoretical, empirical, and interventional implications for future work on the generation of positive experiences in challenging situations.

3.2 Introduction

Negative experiences often occur when people experience difficult situations across diverse domains of human experience, including relationships, work, health, and finances. As research has documented for decades, negative stress experiences can have detrimental effects on physical and mental health, especially when these experiences occur chronically (O'Connor et al., 2021; Schneiderman et al., 2005). On the other hand, positive responses to challenging situations can also occur regularly, for instance when individuals experience accomplishment, effective coping, self-efficacy, and savoring the moment (Epel, 2020).

The distinction between negative and positive stress dates back to Selye's model of Stress-as-Adaptation-Syndrome, characterizing physiological maladaptation to threatening situations as distress and physiological adaptation to challenging situations as eustress (Selye, 1936, 1974). The Transactional Model of Stress extended Selye's distress-eustress distinction to include cognitive processes (Lazarus, 1966; Lazarus & Folkman, 1984; Lazarus & Folkman, 1987). Whereas appraising a difficult situation as exceeding available coping resources can induce distress, appraising a challenge as falling within available resources can induce eustress.

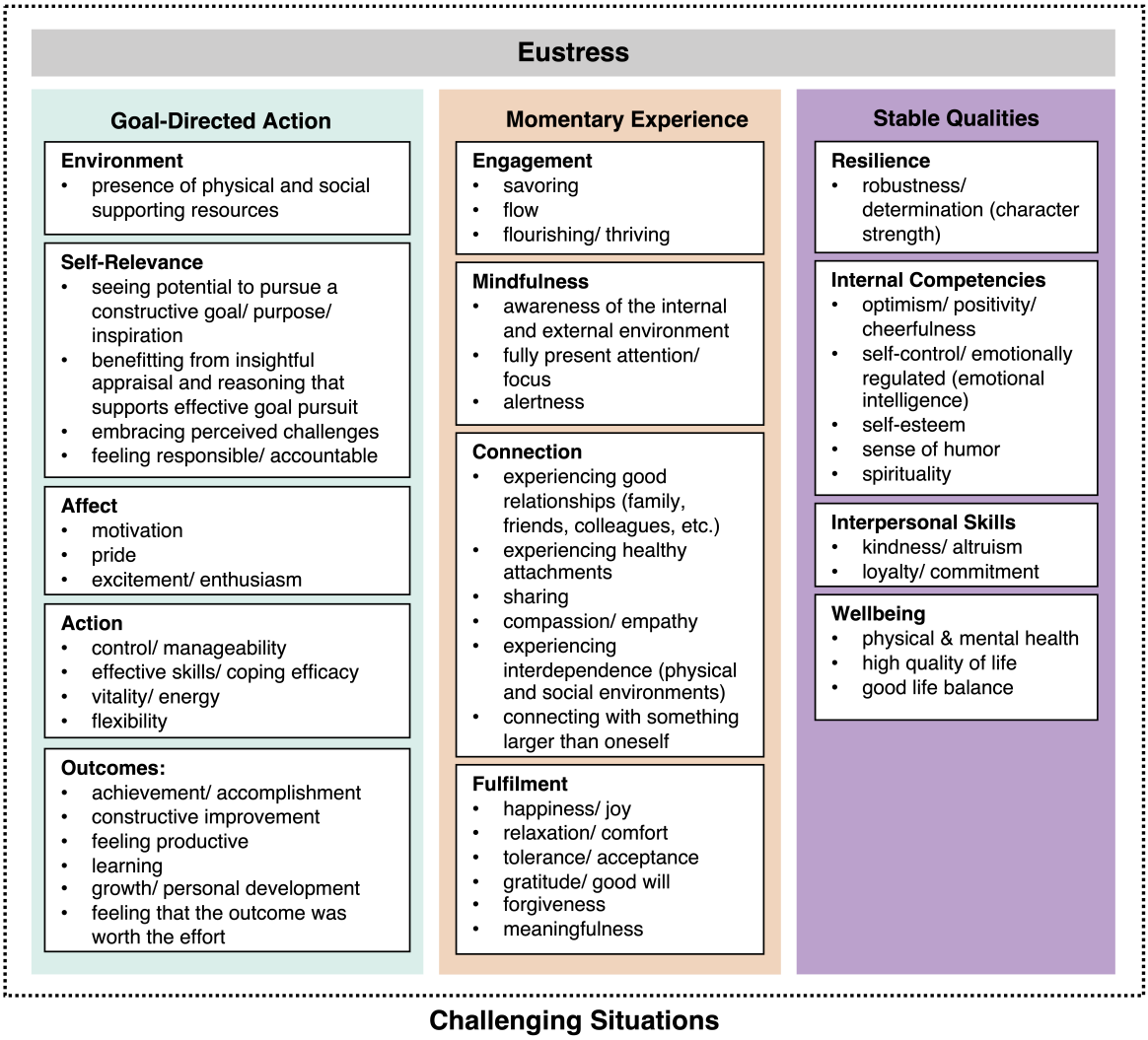
Since these initial conceptualizations of distress and eustress, extensive research has established features that contribute to experiencing a challenging situation negatively, including expectation violation, perceived threat, and rumination (e.g., Lebois et al., 2016). It remains less clear, however, what features contribute to experiencing challenging situations positively. As a consequence, the term "eustress" has remained relatively vague and poorly understood, highlighting the need for more comprehensive theoretical models and measurement instruments (Kloidt & Barsalou, 2024; Le Fevre et al., 2003).

3.2.1 Theories of eustress

Diverse accounts of eustress, along with related evidence, can be found across relevant disciplines, including health psychology, occupational psychology, and educational psychology, and across diverse literatures, including those for basic, clinical, and applied research. Typically, each of these accounts conceptualizes eustress within the context of a specific project and/or research area, contributing useful yet relatively narrow and fragmented understandings of eustress. Comprehensive research on eustress that synthesizes insights and evidence across disciplines and literatures is in its infancy.

Figure 3.1

Comprehensive Hierarchical construct of Eustress (CHE)



Note. At the highest level of organization, three eustress sources are depicted as colored columns (with bolded column headers). Together, the three sources contain a total of 13 mid-level facets, illustrated as white boxes within each column (bolded box headers). Finally, 47 low-level features of eustress are organized into the associated facet boxes (bullet points)

The first model of eustress to integrate cross-disciplinary research comes from Kloidt and Barsalou (2024), who identified 57 unique features of eustress through reviewing 80 theoretical, interventional, empirical, and psychometric articles. Using a deductive approach to theory-building, Kloidt and Barsalou structured the 57 identified features into a three-level hierarchical structure, the Comprehensive Hierarchical construct of Eustress (CHE). Figure 3.1 presents the CHE model (reproduced from Kloidt and Barsalou (2024).

At CHE's highest hierarchical level, eustress emerges from three general sources: goal-directed action, momentary experience, and stable qualities of the individual. At CHE's intermediate level, the three general sources differentiate into 13 facets of eustress, each

containing one to six of the original 57 features extracted from the eustress literature. For 10 of the 13 facets, its most representative feature was used to label the facet. For the other three facets, a new feature was induced to serve as its label. As Kloidt and Barsalou (2024) discuss, the facet labels are closely related to relevant theoretical models. Finally, at CHE's lowest level, the remaining 47 features are nested within the 13 facets. As Figure 3.1 illustrates, CHE's sources, facets, and features capture the diverse forms that eustress states and traits can take across individuals and situations, covering the construct of eustress comprehensively.

According to CHE, one way eustress often occurs in challenging situations is from pursuing goal-directed action successfully, experienced, for instance, as insightful appraisal, effective coping, enthusiasm, and/or productivity. Eustress also results when individuals engage with challenging situations positively in the moment, experienced, for instance, as flow, mindfulness, social connection, and/or fulfilment. Lastly, individuals can develop stable qualities that support generating states of eustress in the moment, thereby making it possible to experience challenging situations positively instead of negatively. Stable qualities that enhance eustress include resilience, self-control, optimism, physical health, and mental health. Importantly, CHE focuses exclusively on generating positive experiences in challenging situations. As a consequence, the construct of eustress remains clearly differentiated from wellbeing, which typically occurs in *non-challenging* situations (although these constructs are also related; Kloidt & Barsalou, 2024).

3.2.2 Psychometric instruments for assessing eustress

Similar to theories of eustress, the development of psychometric instruments for assessing eustress in individuals remains in the early stages. To date, few eustress instruments exist (e.g., Cavanaugh et al., 2000; O'Sullivan, 2011; Rodríguez et al., 2013; Vikoler et al., 2024). Those that do only assess a fraction of the features of eustress established in CHE, thereby only offering partial coverage of the full construct. Existing psychometric instruments are further limited by assessing eustress in specific populations (e.g., students, managers, social workers) and/or in specific contexts (e.g., workplace settings including universities, corporations, or social services). None of the existing measures offer a comprehensive assessment of eustress in the general population across the diverse forms of eustress experience that CHE established. For these reasons, developing a psychometric instrument that assesses eustress comprehensively would be of value, not only for assessing individual differences in psychometric settings, but also in clinical, applied, behavior change, and research settings. Our primary goal here was to develop such an instrument.

3.2.3 The psychometric structure of eustress

Investigations into the psychometric structure of a construct such as eustress typically aim to answer questions about its central features and their factor structure. To measure eustress comprehensively, we used CHE's 47 low-level features to develop 47 analogous items in a psychometric instrument. Because these 47 items capture the diverse forms that eustress takes across populations, contexts, and literatures, they can comprehensively measure an individual's level of eustress. We didn't include CHE's facets and sources as candidate items because the 47 low-level features capture them all well. More importantly, including the facets and sources as test items would have produced unwanted and problematic redundancy in the resulting instrument. One central issue that we investigated in the study to follow is whether all 47 candidate items are relevant to the construct of eustress. Perhaps a subset of these features constitutes a conceptual core, with other features being peripheral (or redundant).

It also remains unclear how the 47 candidate items relate to one another and to the construct space of eustress that CHE established. One possibility is that eustress is a unidimensional construct with all features contributing directly and similarly strongly, as implicitly suggested by traditional definitions of eustress (Lazarus & Folkman, 1984; Selye, 1974). Alternatively, eustress could be a multidimensional construct. Kloidt and Barsalou's (2024) CHE model, for example, proposes that eustress emerges from three distinct sources. Interestingly, these two views need not be mutually exclusive. In a bifactor structure, the eustress construct could contain both a general eustress factor and specific multidimensional factors (cf. general vs. domain-specific intelligence; Deary, 2012). Evaluating our novel instrument allowed us to assess these possibilities.

3.2.4 Relating eustress to distress and wellbeing

Investigating the psychometric structure of a construct typically begins with internal evaluation of it, identifying the best-fitting model, establishing its robustness and assessing its reliability. Also essential is evaluating the construct externally, assessing its relations with related constructs. For external evaluation, eustress has been assessed most prominently in relation to distress, with eustress and distress viewed as opposite poles of the same construct (e.g., Cohen et al., 1983) or as distinct divergent constructs (e.g., Rodríguez et al., 2013). An important question is whether an individual can only experience high distress or eustress in a situation (being highly correlated negatively) or can instead experience high levels of both (being weakly correlated or uncorrelated). The study reported here addressed this issue.

As a second external relation, we also assessed the relation between eustress and wellbeing. As Kloidt and Barsalou (2024) review, trait-level features of eustress and psy-

chological wellbeing overlap conceptually, suggesting that these two constructs should be positively correlated across individuals. These two constructs, however, differ in an interesting way. Whereas eustress focuses exclusively on positive experiences in challenging situations, wellbeing focuses on positive experiences in non-challenging situations. Because of this difference, eustress and wellbeing may not be highly related. The study reported here allowed us to evaluate these possibilities.

3.2.5 Eustress profiles

Establishing the key features and structure of a comprehensive eustress construct informs understanding the basic processes that underlie it, while further supporting interventions to increase eustress in clinical, applied, behavior change, and research settings. Although existing research suggests that eustress can be a highly unique, individual experience (O'Sullivan, 2011; Rodríguez et al., 2013), it is likely that groups of individuals share eustress experiences to some extent. For this reason, it would also be useful if a eustress assessment instrument could also establish profiles of reliable differences at the group level, where different individuals exhibit similar eustress profiles.

The possibility that groups of individuals exhibit different eustress profiles follows from a person-centered approach to positive emotions, suggesting that individuals can be broadly categorized into "flourishers" and "languishers" depending on their capacity to engage positively with the moment and build resilience, personal resources, and wellbeing over time (cf. broaden-and-build theory; Fredrickson & Joiner, 2002; Keyes, 2002). Although it can also be useful to establish an idiosyncratic profile of eustress for each individual, establishing group profiles can offer insights into understanding general processes that contribute to a construct (including shared genes, environments, and/or epigenetic history), support generalizations across individuals, and guide precision medicine interventions for specific kinds of individuals.

3.2.6 Study overview

The current work aimed to address the theoretical and applied issues presented above. To do so, we developed a novel psychometric instrument that assesses eustress in the general UK population across challenging situations (i.e., not in specific populations or contexts). The Comprehensive Hierarchical Eustress Review (CHER) developed here contains 47 items that reflect CHE's 47 low-level features (Figure 3.1). These 47 items were further organized into three subscales reflecting CHE's three multidimensional sources of eustress. To evaluate CHER, we assessed it in a well-powered sample of UK adults, together with psychometric instruments that measure related constructs.

Three research questions (RQs) were of primary interest:

RQ1. What psychometric model best describes eustress as measured by CHER? Unidimensional, multidimensional, or both (bifactor)?

RQ2. Does CHER's best performing model exhibit desirable internal and external psychometric qualities?

RQ3. Can CHER's best performing model be used to organize individuals into distinct clusters that reflect distinct group-level profiles of eustress?

To address RQ1, we first investigated how to best model the factor structure that underlies eustress, using confirmatory factor analysis on the dataset collected with CHER here. If eustress is best understood as a simple unidimensional construct, then a one-factor model should offer an excellent fit to the 47 features of eustress that CHER assesses. Alternatively, the structure of eustress could reflect CHE's three multidimensional sources: goal-directed action, momentary experience, and stable qualities. If so, then a three-factor model should offer an excellent fit of the data collected with CHER. Still another possibility is that eustress reflects both a general eustress factor, accompanied by specific multidimensional factors. If so, then a bifactor model should fit the data collected with CHER well.

To address RQ2, we evaluated the best-fitting model from RQ1 internally and externally. For internal evaluation, we established CHER's test reliability and item discriminatory power. For external evaluation, we assessed the relationship between CHER's measure of individual eustress with another measure of eustress, and also with measures for distress and wellbeing.

To address RQ3, we used latent profile analysis to identify different groups of individuals who shared differed eustress profiles on CHER. Specifically, we established groups who exhibited similar patterns across factor scores from the best-fitting model in RQ1. We then investigated whether belonging to a specific cluster was systematically associated with sociodemographic characteristics, personality traits, distress, and wellbeing.

3.3 Methods

3.3.1 Participants

This study received ethics approval from the College of Medical Veterinary and Life Sciences at the University of Glasgow (application 200230250). We recruited a gender-balanced, non-probabilistic sample through the Prolific online platform that met the following inclusion criteria: UK residents, aged 18 to 80 years old, self-reported English fluency, and completion of at least 20 Prolific studies with a 100% approval rate. We recruited 260 participants to meet minimum requirements for stable correlations ($n > 250$;

Schönbrodt & Perugini, 2013) and to ensure convergent solutions for confirmatory factor models ($n > 100$; MacCallum et al., 1999) and bifactor models ($n > 150$; Bader et al., 2022). We inspected our data for mechanical or random responses but refrained from excluding outliers, as we expected highly variable distributions reflecting large individual differences.

All participants passed data quality checks that checked for random and mechanical responding, resulting in a final sample of 260 UK adults (128 male, 127 female, 3 genderqueer/ non-binary, 2 prefer not to say) with a mean age of 44.60 years ($SD = 13.60$). Participants spent a mean time of 15 years ($SD = 3.03$) in formal education and most commonly reported that their annual income ranged from £20,001 to £30,000 ($n = 69$), with both measures approximating UK population levels (Office for National Statistics, 2021, 2025).

3.3.2 Materials

Comprehensive Hierarchical Eustress Review

The CHER psychometric instrument contains 47 self-report items that closely reflect the 47 low-level eustress features of the Comprehensive Hierarchical construct of Eustress (CHE) illustrated in Figure 3.1. As described earlier, these features were derived from a scoping review of the eustress literatures (Kloidt & Barsalou, 2024). Table 3.1 presents CHER's 47 test items.

Following CHE's hierarchical structure, we grouped similar test items into distinct facets and then organized facets into three subscales reflecting CHE's general sources of eustress: goal-directed action (18 items), momentary experience (18 items), and stable qualities of the individual (11 items). As Table 3.1 illustrates, we integrated subscale affiliations into the wording of the survey items, given that doing so was necessary for conveying the content of each item accurately. Items were evaluated on a continuous self-report scale with one decimal point precision, ranging from 0 (not at all) to 10 (a lot).

Table 3.1

The 47 test items in the Comprehensive Hierarchical Eustress Review (CHER), clustered by source and facet

Subscale/ Facet/ Item (Label)	***M***	***SD***
Goal-directed action	**6.93**	**2.10**
When pursuing personal goals in challenging situations...		
Environment		

Subscale/ Facet/ Item (Label)	***M***	***SD***
1. ... how much do you benefit from physical and social support in your environment? (*physical / social support*)	6.45	2.42
Self-relevance		
2. ... how much do you benefit from your ability to think and reason effectively? *(think / reason effectively)*	7.67	1.88
3. ... how much do you benefit from your ability to construct insightful appraisals of the current situation? *(insightful appraisals)*	6.76	1.99
4. ... how much do you benefit from your ability to embrace perceived challenges? *(embrace challenges)*	6.33	2.19
5. ... how much do you benefit from feeling responsible and accountable? *(responsible / accountable)*	6.74	2.18
6. ... how much do you benefit from seeing the potential to pursue a meaningful purpose or inspiration? *(purpose / inspiration)*	6.55	2.11
Affect		
7. ... how much do you benefit from feeling motivated and confident? *(motivated / confident)*	7.23	2.13
8. ... how much pride do you experience? *(pride)*	6.12	2.32
9. ... how much do you benefit from feeling excited and enthusiastic? *(excited / enthusiastic)*	6.09	2.48
Action		
10. ... how much do you benefit from having control over the situation? *(perceived control)*	7.58	1.83
11. ... how much do you benefit from having effective coping skills when these situations arise? *(coping skills)*	7.13	2.07
12. ... how much do you benefit from having vitality, energy, and personal strength? *(vitality / energy / strength)*	6.88	2.16
13. ... how much do you benefit from being flexible and adapting to the situation? *(flexible / adapting)*	7.28	1.89
Outcomes		
14. ... how much do you benefit from feeling productive? *(productivity)*	7.51	1.75
15. ... how much do you feel that the outcome was worth the effort? *(outcome worth effort)*	7.14	1.92
16. ... how much do you experience personal improvement, growth, and development? *(improvement / growth / development)*	6.65	1.90
17. ... how much does what you've learnt impact your future goal pursuit? *(learning)*	7.19	1.69

Subscale/ Facet/ Item (Label)	***M***	***SD***
18. . . . how much do you experience a sense of accomplishment? *(accomplishment)*	7.45	1.77
Momentary experience When experiencing challenging situations. . .	**5.22**	**2.56**
Engagement		
19. . . . how much do you find yourself savouring the moment? *(savoring)*	3.76	2.54
20. . . . how much flow do you experience in the moment? *(flow)*	5.15	2.14
21. . . . how much do you find yourself flourishing and thriving in the moment? *(flourishing / thriving)*	5.00	2.40
Mindfulness		
22. . . . how mindful are you of your internal and external environment in the moment? *(mindful)*	5.86	2.24
23. . . . how much do you find yourself fully present and focused in the moment? *(present / focused)*	7.00	2.03
24. . . . how alert are you in the moment? *(alert)*	7.75	1.75
Connection		
25. . . . how much are you aware of having good relationships in the moment? *(good relationships)*	5.62	2.54
26. . . . how much are you aware of having healthy social attachments in the moment? *(healthy attachments)*	4.84	2.38
27. . . . how much do you experience sharing with others in the moment? *(sharing)*	5.18	2.51
28. . . . how much do you experience compassion and empathy with others in the moment? *(compassion / empathy)*	6.03	2.47
29. . . . how much inter-dependence with your physical and social environments do you experience in the moment? *(inter-dependence)*	5.50	2.20
30. . . . how much do you experience connecting with something larger than yourself in the moment? *(larger than self)*	4.19	2.61
Fulfilment		
31. . . . how much do you experience happiness and joy in the moment? *(happiness / joy)*	4.20	2.38
32. . . . how much do you experience relaxation and comfort in the moment? *(relaxation / comfort)*	3.14	2.43
33. . . . how much do you experience tolerance and acceptance in the moment? *(tolerance / acceptance)*	5.59	2.24

Subscale/ Facet/ Item (Label)	***M***	***SD***
34. . . . how much do you experience gratitude and goodwill in the moment? *(gratitude / goodwill)*	5.05	2.37
35. . . . how much do you experience forgiveness towards yourself or others in the moment? *(forgiveness)*	4.98	2.43
36. . . . how much do you experience meaningfulness in the moment? *(meaningfulness)*	5.11	2.24
Stable qualities of the individual When you think about yourself across the challenging situations in your life. . .	**5.78**	**2.66**
Resilience		
37. . . . how resilient are you? *(resilience)*	7.02	2.30
Interpersonal skills		
38. . . . how kind and altruistic are you? *(kind / altruistic)*	6.25	2.16
39. . . . how loyal and committed are you? *(loyal / committed)*	7.45	1.89
Internal competencies		
40. . . . how optimistic, positive, and cheerful are you? *(optimistic / positive / cheerful)*	5.39	2.50
41. . . . how controlled and emotionally regulated are you? (self-control)	5.96	2.43
42. . . . how much self-esteem do you have? *(self-esteem)*	5.34	2.59
43. . . . how much of a sense of humour do you have? *(humor)*	6.10	2.67
44. . . . how spiritual are you? *(spirituality)*	3.21	3.11
Wellbeing		
45. . . . how much physical and mental wellbeing do you have? *(wellbeing)*	5.60	2.29
46. . . . how high is your quality of life? *(quality of life)*	5.66	2.36
47. . . . how much work-life balance do you have? *(work-life balance)*	5.61	2.54

Note. Participants rated items on continuous 0 to 10 self-report scales (one decimal place precision) with lower scores indicating lower levels of eustress. Scale labels were "not at all" (0), "moderately" (5), and "a lot" (10). To better fit the wording of the items for *pride*, *self-esteem*, *humor*, *wellbeing*, and *work-life balance*, the labels used were "none" (0), "moderately" (5), and "a lot" (10); similarly, the item for *quality of life*, used the labels "very low" (0), "moderate" (5), and "very high" (10). Please refer to supplemental materials SM-1 on OSF for additional item-level descriptives. M = mean; SD = standard deviation. $N = 260$

Perceived Stress Scale (PSS-10; Cohen et al., 1983)

The 10-item PSS measures how much distress individuals experienced during the last month. Items were evaluated on a continuous self-report scale with one decimal point precision, ranging from 0 (never) to 4 (very often). Across several studies, the PSS-10 has exhibited satisfactory test reliability ($\alpha = .74$–$.91$) and test-retest reliability ($r > .70$; Lee, 2012). In our sample here, the PSS-10 exhibited excellent test reliability ($\alpha = .94$).

Perceived Eustress Scale (PES-10)

The PES is an unpublished instrument that was developed and evaluated in our research group (presented in the supplemental materials SM-2 on OSF). Designed to have analogous structure and content in relation to the PSS, the 10-item PES assesses how much eustress individuals experienced during the past month. Items were evaluated on a continuous self-report scale with one decimal point precision, ranging from 0 (never) to 4 (very often). In a three-timepoint study over two weeks, the PES-10 exhibited satisfactory test reliability ($\alpha = .84$) and adequate test-retest reliability that appeared to also reflect systematic change in eustress across the two-week period ($r = .63$–$.68$). In our sample here, the PES-10 exhibited a similarly satisfactory test reliability ($\alpha = .85$).

European Social Survey Wellbeing Module (ESS Wellbeing; Huppert & So, 2013)

The 10-item ESS Wellbeing instrument assesses 10 dimensions of psychological wellbeing that were evaluated in a representative sample of 43,000 Europeans from 23 countries (Huppert & So, 2013). Items were evaluated on continuous self-report scales here with one decimal point precision. To account for differing response scales and item weights, we computed standardized factor scores with higher scores representing increased wellbeing (Ruggeri et al., 2020). In our sample here, the ESS Wellbeing exhibited satisfactory test reliability ($\alpha = .83$).

(HEXACO-60; Ashton & Lee, 2009)

The 60-item HEXACO instrument assesses personality traits along the six dimensions of honesty, emotionality, extraversion, agreeableness, conscientiousness, and openness. Items were evaluated here on a continuous self-report scale with one decimal point precision, ranging from 1 (strongly disagree) to 5 (strongly agree). All subscales have shown satisfactory test reliability ($\alpha = .73$–$.80$) and test-retest reliability ($r = .82$–$.89$) in a large adult sample (Henry et al., 2022). In our sample here, the test reliabilities of the HEXACO subscales ranged from from .79 (honesty) to .87 (extraversion).

Socioeconomic characteristics

We collected socioeconomic information that included time spent in formal education (ranging from 0 to 20+ years) and annual income (divided into £10,000 increments ranging from "below £10,000" to "above £50,000"). We further measured subjective social status with the MacArthur Scale (Adler et al., 2000), where participants placed themselves on a 10-rung ladder representing where people stand in the United Kingdom (with higher rungs indicating higher subjective social status). This measure has exhibited adequate test-retest reliability in a large multi-ethnic sample (r = .62; Operario et al., 2004).

3.3.3 Procedure

Following recruitment via Prolific, participants were referred to the Qualtrics platform, where they provided informed consent and completed the survey online. In a within-group design, all participants completed the CHER scale, followed by the HEXACO-60, the PSS-10, the PES-10, the ESS Wellbeing, and sociodemographic questions. For each individual, the 47 CHER items were presented in a random order to break up items from the same subscale. Items in all other psychometric instruments were presented in a fixed order, as typically followed when implementing them. After study completion (Mdn = 20 min, IQR = 10–29 min), participants were debriefed, redirected back to Prolific, and compensated with £2.50.

3.3.4 Data analysis

We performed statistical analyses in R (v4.3.2; R Core Team, 2023) and RStudio (v2023.12.1+402; RStudio Team, 2022), with the packages tidyverse (Wickham et al., 2019), psych (Revelle, 2024), lavaan (Rosseel, 2012), and tidyLPA (Rosenberg et al., 2018). We have uploaded supplementary materials to the Open Science Framework, including raw data, analysis files, and the supplemental results files referred throughout. They can all be accessed here: https://osf.io/s7mgy/

3.4 Results

3.4.1 RQ1: Modelling the psychometric structure of eustress

To investigate the psychometric structure of eustress, we performed a series of confirmatory factor analyses. Specifically, we first assessed models with a single factor (implying that eustress is unidimensional) versus models with multiple correlated factors (implying that eustress is exclusively multidimensional). We then implemented a bifactor model to

address whether the structure of eustress simultaneously reflects a general factor and three group factors for CHE's three sources of eustress (Reise, 2012; Reise et al., 2010).

Because CHER is a novel instrument, we also examined whether all 47 items are essential for capturing the construct of eustress and removed poorly loading items from our initial factor solutions. To strike a reasonable balance between conservative item cut-offs (keeping the most conceptually important items only; Tabachnick & Fidell, 2007) versus liberal cut-offs (retaining a comprehensive sample pool of items; Stevens, 1992), we employed stepwise removal of items with main factor loadings $< |.50|$. The chosen cut-off therefore only retained items for which the factor explained at least 25% of variance, a figure obtained through squaring its loading (cf. Brown, 2015).

To evaluate how well the CHER data fit each model's predicted structure, we report the following fit indices: comparative fit index (CFI), Tucker-Lewis index (TLI), root mean squared error of approximation (RMSEA), Bayesian information criterion (BIC), and Akaike information criterion (AIC). For acceptable fit, CFI and TLI should be $> .90$ whereas RMSEA should be $< .08$ (Brown, 2015). Lower relative values for the BIC and AIC indicate more parsimonious solutions. Factor loading tables for all initial models with all 47 items are available in the supplemental materials (Tables SM-3, SM-4, SM-5).

Model 1 (unidimensional)

We first investigated whether a traditional definitional understanding can sufficiently cover the construct of eustress. Thus, this first model (M1) consisted of one general factor in a confirmatory factor analysis, assuming that eustress is a unidimensional construct without any specificity that reflects multidimensionality. Although all 47 items of the CHER instrument loaded positively on the eustress factor, 10 item loadings were below the enforced cut-off at .50 (again, all loadings can be found in SM-3). The stepwise removal of these items resulted in a factor solution that contained 37 items (Figure A.1 in the Appendix). Their mean factor loading was .63, with the single latent eustress factor explaining 40.41% of the total item variance. Although the large mean factor loading indicates meaningful measurement of a general eustress construct, model fit was not acceptable according to our fit criteria, CFI = .723, TLI = .707, RMSEA (90% confidence interval) = .099 (.095–.104), with relative fit values BIC = 38,447 and AIC = 38,183. We therefore investigated whether a multidimensional model—as predicted by CHE—fits the structure of eustress better.

Model 2 (multidimensional)

The second model (M2) assessed CHE's structure in Figure 3.1, examining whether multiple factors for goal-directed action, momentary experience, and stable qualities capture the structure of eustress effectively. Specifically, M2 implemented a confirmatory

factor analysis that assessed how these three CHER subscales fit the data. Items could only load onto their respective factor, but we permitted inter-factor correlations to capture potential overlap between M2 factors. After removing seven items with factor loadings $<$ .50, 17 items loaded on the goal-directed action factor, 15 on the momentary experience factor, and eight on the stable qualities factor (see Figure A.2; all loadings can be found in SM-4).

Compared to M1, M2 retained more items and exhibited higher mean factor loadings of .68 for goal-directed action, .67 for momentary experience, and .70 for stable qualities. M2 explained 46.54% of total item variance (more than M1) and exhibited improved (yet not satisfactory) model fit for CFI = .829, TLI = .819, and RMSEA (90% *CI*) = .074 (.069–.078), but worse fit for BIC = 41,334, and AIC = 41,038. These results indicate that CHE's theory-driven multidimensional structure captured CHER's diverse item pool somewhat better than a unidimensional structure. Nevertheless, strong inter-factor correlations (M = .76, range = .67-.81) suggested poor discriminant validity between the factors, implicating the presence of a general factor in the data set that complemented multidimensionality at the group-level (i.e., taking the form of specific factors for CHE's three sources). To assess this possibility, we combined M1 and M2 into a bifactor model, assessed next.

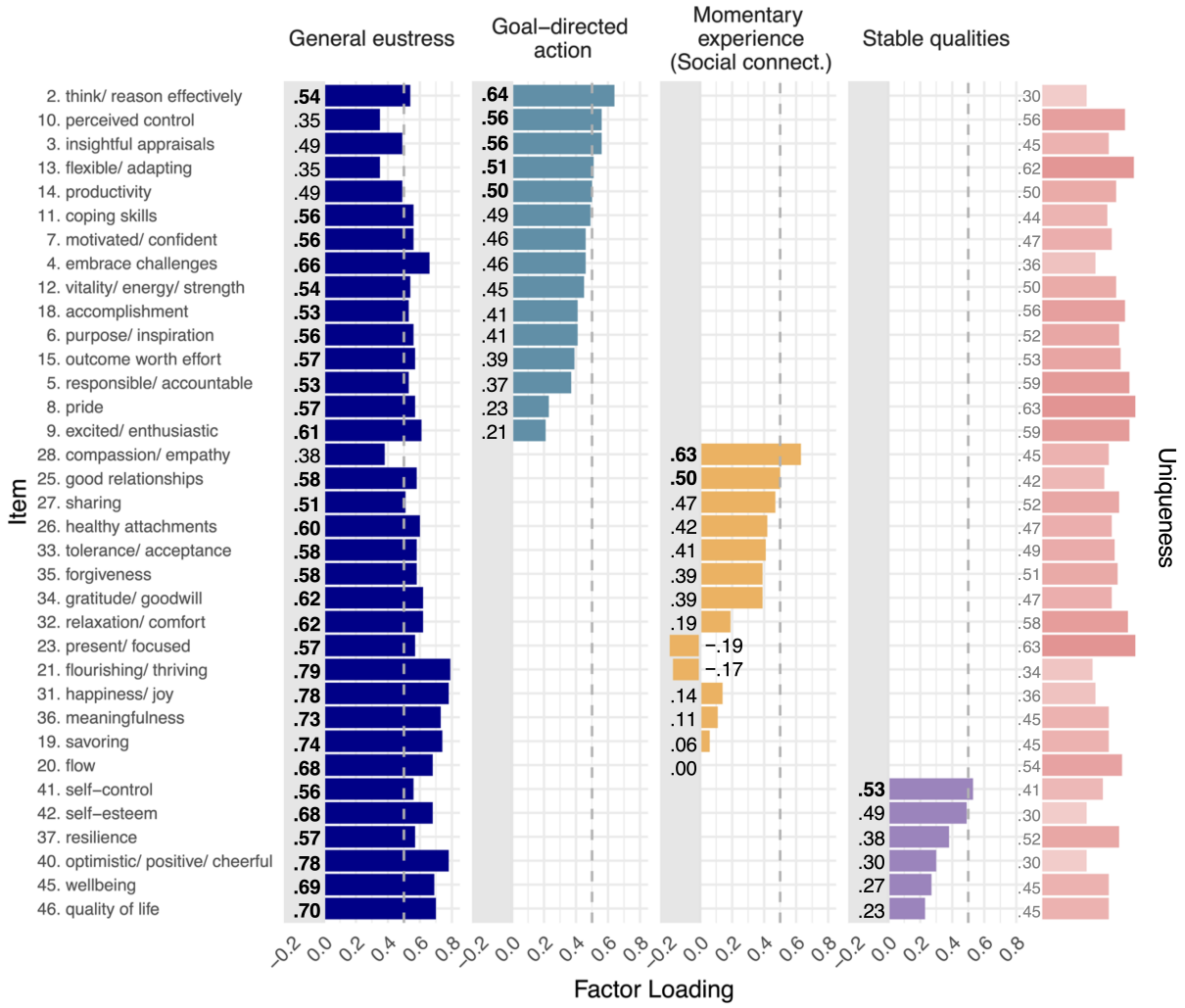
Model 3 (bifactor)

Of primary interest here was whether a general eustress factor is present in the dataset, as the high correlations between the three M2 factors suggest. Because M1 ruled out a single factor model, this third model (M3) allowed for the general factor to be accompanied by group factors that represent CHE's three multidimensional subscales for goal-directed action, momentary experience, and stable qualities. M3 therefore included the same three-factor structure as M2 but with an additional general eustress factor. All factors were orthogonal, ensuring high discriminant validity.

Whereas the initial 47-item bifactor model had limited conceptual interpretability due to *negative* factor loadings for some items $\geq |.50|$, the stepwise removal of 12 weakly loading items $< |.50|$ resulted in a clearly interpretable solution with all meaningful loadings being positive (SM-5 presents all loadings). As Figure 3.2 illustrates, the general eustress factor included all the remaining 35 items. Additionally, the group factor for goal-directed action included 15 items; the group factor for momentary experience included 14 items; and the group factor for stable qualities included six items. M3 accounted for 52.17% of total variance (more than M1 and M2) and close-to-acceptable model fit, CFI = .881, TLI = .865, RMSEA (90% *CI*) = .069 (.064–.075), with BIC = 35,966, and AIC = 35,592, lower than for either previous model.

Figure 3.2

Factor loading plot for Model 3 (bifactor)



Note. M3 captured 35 of CHER's original 47 items, with main factor loadings for them ≥ |.50| (dashed gray line). The general eustress factor included all 35 items, with the three group-level factors containing subsets of the 35 items, specifically, goal-directed action (15 items), momentary experience (14 items), stable qualities (six items). M3 accounted for 52.17% of total variance, with most variance explained by general eustress (68.96%) followed by goal- directed action (17.15%), momentary experience (9.07%), and stable qualities (4.82%). Factor loadings ≥ |.50| are bolded. Light gray rectangles distinguish negative factor loadings. Social connect. = Social connection. $N = 260$

The general eustress factor in M3 explained 68.96% of the extracted common variance and had a mean factor loading of .59, which was comparable to the mean factor loading in the unidimensional solution M1 ($\lambda_{mean} = .63$). The three group factors captured residual variance in their respective items after the general factor first accounted for common variance across all items. For goal-directed action and stable qualities, all their respective items exhibited meaningful loadings on the respective group-factor ($\lambda_{mean} = .44$ and .37,

respectively). For momentary experience, items related to social connection exhibited meaningful loadings ($\lambda_{mean} = .50$), whereas loadings for the remaining items did not ($\lambda_{mean} = .13$). It therefore appears that the momentary experience factor in the bifactor model captured social connection, whereas all the remaining features associated with (non-social) momentary engagement were captured by the general eustress factor. M3 therefore suggests that the construct of eustress, as measured with CHER, is best represented by a general factor (emphasizing momentary engagement and stable qualities) and three group factors for goal-directed action, momentary experience (emphasizing social connection), and stable qualities.

Model comparison and selection

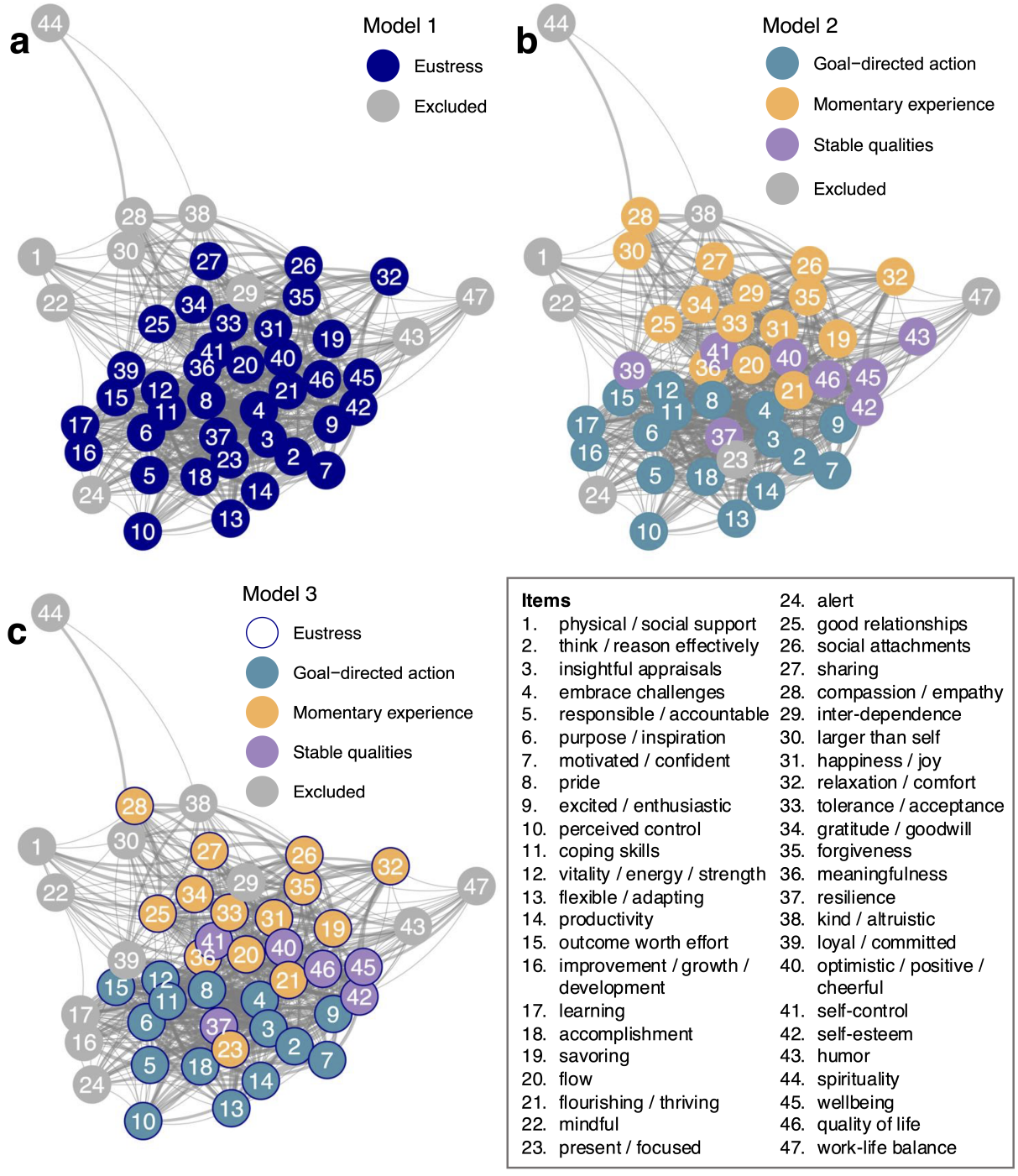
To better understand the components and structure of the three models, we visualized the 2,162 pairwise correlations between the 47 CHER items in a network plot for each. Figure 3.3 presents the results, with colored nodes representing items included in each of the three confirmatory models, and with gray nodes representing excluded items (included here to further motivate their exclusion from the confirmatory models, but not included in any subsequent analyses). What is perhaps most striking across the three plots is that the included items form a single large cluster in the center of the network, with the excluded items dispersed around its periphery.

Across network plots, the highly inter-correlated core of the network essentially constitutes the general eustress factor in the M1 and M3 models. What is striking about this core, however, is that it contains well-segregated regions for CHE's three multidimensional sources of eustress. Specifically, as the panels for M2 and M3 illustrate, properties associated with momentary experience reside at the top of the core cluster, properties associated with goal-directed action reside at the bottom, and properties associated with stable qualities reside on the boundary between these two clusters, especially on the right. In other words, a general core construct of eustress consists of three components, each constituting one of CHE's three sources of eustress.

We next proceeded to formally establish the best-performing model for further analysis, striving for balance between reasonable model fit criteria and conceptual interpretability. Although M1 established that a general factor meaningfully explains shared variance across the measurement items, model fit was inadequate. From the additional perspectives of M2 and M3, M1's poor fit reflects the fact that it doesn't capture the multidimensional structure embedded within the core eustress construct (Figure 3.3). We therefore dismissed M1, rejecting the assumption that eustress, as measured with the CHER scale, is exclusively unidimensional.

Figure 3.3

Network plots illustrating the construct space of eustress with different clustering solutions



Note. Nodes depict the 47 items of the CHER scale with node labels specifying corresponding CHER features. Same-colored nodes depict the factor(s) in Model 1 (**a**), Model 2 (**b**), and Model 3 (**c**). For Model 3 (**c**), dark blue node outlines indicate the general eustress factor in addition to group factors (coloured node fill). Gray nodes depict weakly-loading items that were excluded during model fine-tuning. Edges depict Spearman correlations between item pairs $> .30$ with wider edges indicating larger correlations. $N = 260$

In comparison to M1, the correlated factors in M2 retained more items, explained more item variance, had better model fit (except for BIC and AIC values), and reflected the existing CHE model of eustress. Nevertheless, M2 exhibited strong inter-factor correlations, suggesting that a general factor does indeed underlie eustress, consistent with M1. Because M2 failed to capture this core factor, we therefore dismissed M2, together with the assumption that eustress, as measured with the CHER scale, is exclusively multidimensional.

Combining the general factor of M1 with the theory-based factors of M2, the bifactor model M3 explained the most total variance and exhibited the best model fit, including substantially lower values for BIC and AIC. We note that the model fit indices CFI and TLI were just slightly below acceptable cut-offs, possibly indicating unstable values that reflect our sample size (Garrido et al., 2016). M3 also provided a compelling factor structure. Specifically, all M3's 37 included items loaded on the general factor for eustress. Additionally, all items associated with goal-directed action and stable qualities loaded meaningfully on their respective group factor. Interestingly, however, only half the items for momentary experience loaded meaningfully on its group factor, namely, the items related to social connection. All the other items *not* related to social connection were related to momentary engagement instead. Because the general factor explained most of the variance associated with these latter items , it follows that momentary engagement was central to the general eustress factor. Indeed, as Figure 3.2 illustrates, the highest-loading items on the general eustress factor were those related to momentary engagement.

For M3, the general factor captured the highest proportion of explained item response variance (68.96%), again, with momentary engagement items from the momentary experience subscale being most important, together with items for stable qualities (Figure 3.2). M3 further benefitted from group factors for goal-directed action, momentary experience (social connection), and stable qualities, accounting for an additional 17.15%, 9.07%, and 4.82% of the explained variance, respectively.

To ensure that M3 is robust under our sample size, we ran 500 Monte-Carlo simulations of our final bifactor solution post hoc. The results exhibited a highly satisfactory convergence rate of 100%, where the same factor structure presented above was observed. Additionally, estimates of the explained common variance for the general eustress factor on average exceeded population values by 0.001, corresponding to an acceptable relative bias of –0.001 (for a tutorial, see Bader et al., 2022). Based on the overall pattern of results for M3, we selected it as the best-performing model. We further concluded that eustress is primarily unidimensional and also somewhat multidimensional, with a core set of items robustly capturing a general eustress construct that is further partitioned into weaker components for CHE's three sources of eustress (Figure 3.3).

3.4.2 RQ2: Evaluating the best performing model internally and externally

Having selected M3 as the best-performing model, we next evaluated it internally (establishing its test reliability, the proportion of variance attributable to the general factor, and discriminatory power) and externally (comparing it with related instruments for distress, eustress, and wellbeing).

Internal validation

We first calculated coefficient alpha (α) to establish the test reliability of M3's factor scores (Shrout & Fleiss, 1979). Across factors, α was highly acceptable: .89 for stable qualities, .92 for momentary experience, .93 for goal-directed action, and .96 for general eustress. Because our measure was not designed to be tau-non-equivalent, we could not estimate its internal consistency with α. We instead calculated coefficient omega hierarchical (ω_h) to investigate how well the total scores for M3 measured a saturated core construct of eustress across all factors (Flora, 2020; Reise et al., 2010). For M3, the proportion of total-score variance accounted for by the general factor (despite the multidimensional nature of the instrument) was .85, again exhibiting an acceptable value.

We next assessed the discriminatory power of the 35 CHER items in M3 using item-total correlations between each specific item and its corresponding factor score (excluding the respective item). Positive coefficients indicate that individuals with a high factor score are more likely to endorse the item, whereas coefficients close to zero or below zero indicate that the item discriminates poorly between individuals with high versus low factor scores. Table SM-6 shows that all item-total correlations with the M3 factor scores exhibited satisfactory discriminatory power, with mean correlations ranging from .62 (general eustress) to .71 (stable qualities). Three items (*flexible / adapting*, *perceived control*, *compassion / empathy*) had reduced item-total-correlations with the general factor, reflected in their peripheral network location (Figure 3.3c). In addition, the item present / focused had a reduced item-total-correlation with its specific factor, again reflected by its distanced position to other items from the momentary experience subscale (Figure 3.3c).

External evaluation

To evaluate M3 externally, we assessed whether M3's factors exhibited the expected relationships with related psychometric measures of distress, eustress, and wellbeing. Specifically, we correlated the factor scores for M3 with the Perceived Stress Scale (PSS-10; Cohen et al., 1983), the Perceived Eustress Scale, and the ESS Wellbeing Module (ESS Wellbeing; Huppert & So, 2013). Table 3.2 illustrates that—in line with our predictions—the general eustress factor exhibited a significantly negative correlation with the

PSS-10 and significantly positive correlations with the PES-10 and the ESS Wellbeing, indicating satisfactory discriminant and convergent qualities, respectively.

Table 3.2

Model 3 (bifactor): Spearman correlations with related constructs

	General eustress	**Goal-directed action**	**Momentary experience**	**Stable qualities**	**PSS-10**	**PES-10**
General eustress	–					
Goal-directed action	.07	–				
Momentary experience	.07	–.14	–			
Stable qualities	.10	$.25^{a}$	–.12	–		
PSS-10	$–.50^{***}$	–.07	.05	$–.45^{a}$	–	
PES-10	$.54^{***}$	.15	.11	.10	$–.41^{a}$	–
ESS Wellbeing	$.62^{***}$	.16	.10	$.33^{a}$	$–.74^{a}$	$.58^{a}$

Note. Spearman correlations between participants' standardized M3 factor scores, Perceived Stress Scale (PSS-10), Perceived Eustress Scale (PES-10), and the European Social Survey Wellbeing Module (ESS Wellbeing). $N = 260$. Significant correlations for one-sided confirmatory predictions are marked with $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. Significant correlations for two-sided exploratory analyses with Bonferroni correction ($\alpha = .05 \ / \ 18$) are marked with a $^{a}p < .003$. Unmarked correlations reflect non-significant exploratory analyses

Notably, general eustress correlated most strongly with psychological wellbeing, indicating that individuals' positive experiences may be similar in both challenging and non-challenging situations (see Kloidt & Barsalou, 2024, for relevant discussion). The moderate correlations of the PSS with M3's general eustress factor and with the PES indicate that distress and eustress are not mirror images of each other but differ to some extent. The moderate correlation of the general eustress factor with the PES probably reflects the fact that the PES primarily contains items related to goal-directed action but not to momentary experience or stable qualities (see SM-2).

In contrast to the general eustress factor, exploratory analyses revealed few relations between group-factors and external measures. Stable qualities exhibited sizeable and significant correlations with the PSS-10 and the ESS Wellbeing in the same directions as the general eustress factor, potentially because the three measures assess related constructs at the trait level. In contrast, the group factors for goal-directed action and momentary experience didn't exhibit any significant relationships with the other measures. These results are not surprising, given that group factor scores in a bifactor model represent residual variance between subgroups of items after first contributing to common variance for the general factor. As a result, an item's residual variance may often be only weakly related or non-related to a group-level factor. Additionally for momentary experience, only half of the items contributed meaningful loadings on this group-level factor, whereas

the other weakly loading items may have created noise. Modest correlations of the group factors may therefore be attributed to structural requirements of the underlying model rather than to limited conceptual importance.

3.4.3 RQ3: Identifying individuals who exhibit distinct profiles of eustress

To examine whether groups of individuals with distinct eustress profiles exist within our sample, we conducted a series of latent profile analyses. Specifically, we used individual factor scores from the best-performing model M3 (bifactor model) as indicator variables to cluster individuals who exhibit similar configurations of eustress factor scores. Once we established latent profiles, we assessed whether individuals across clusters differed systematically in terms of sociodemographic characteristics, personality traits, distress, and wellbeing. To do so, we entered variables of interest as predictors into a multinomial logistic regression model.

Distinct profiles of eustress

Using maximum likelihood estimation, we initially estimated latent profile solutions ranging from one to six distinct clusters of individuals. Table A.1 in the Appendix presents comparisons of these candidate solutions that consider convergence issues, model fit statistics (i.e., information criteria, likelihood-ratio tests, and Bayesian indices), and diagnostic criteria (i.e., class size, average latent class probability, and entropy). After dismissing the 5-cluster solution due to convergence issues, we identified the 4-cluster solution as the best fitting model according to most fit statistics, including the Bayesian information criterion (BIC), consistent Akaike information criterion (CAIC), and Bayes factor (BF). The 4-cluster solution presented with acceptable average latent class posterior probabilities (range = .684 – .916) and entropy (.732), suggesting appropriately separated clusters.

Figure 3.4 presents the eustress profiles, showing the distributions of factor scores from M3 across participants assigned to each of the four identified clusters. Because factor scores are standardized, a factor score of 0.5 indicates that the score is 0.5 SD above the average score of the entire sample (anchored at zero). Vice versa, a factor score of –0.5 indicates that the score is 0.5 SD below sample average. Profile 1 represents the largest cluster containing 58% of participants. Participants assigned to this cluster can be described as *"eustress generalists,"* because they experience above-average levels of general eustress and about-average levels for all other factors. Profile 2 (16% of participants) represents individuals with below-average eustress scores across all factors. Compared to all other profiles, individuals from profile 2 have the lowest mean scores for three out of four factors—general eustress, goal-directed action, and stable qualities. These indivduals

can therefore be construed as *"eustress minimalists"*. Profile 3 (17% of participants) represents *"eustress achievers,"* who experience high levels of eustress while pursuing goals and also internalize eustress as a stable quality but score far below-average on momentary experience items that emphasize social connection. Finally, profile 4 (8% of participants) represents individuals who present with above-average scores of eustress across all the group-level factors but not the general eustress factor. Notably, individuals assigned to this profile experience the highest mean levels of goal-directed action and momentary experience compared to individuals from all other profiles. Individuals from profile 4 may therefore be described as *"eustress specialists"*, thereby contrasting with *"eustress generalists"* from profile 1.

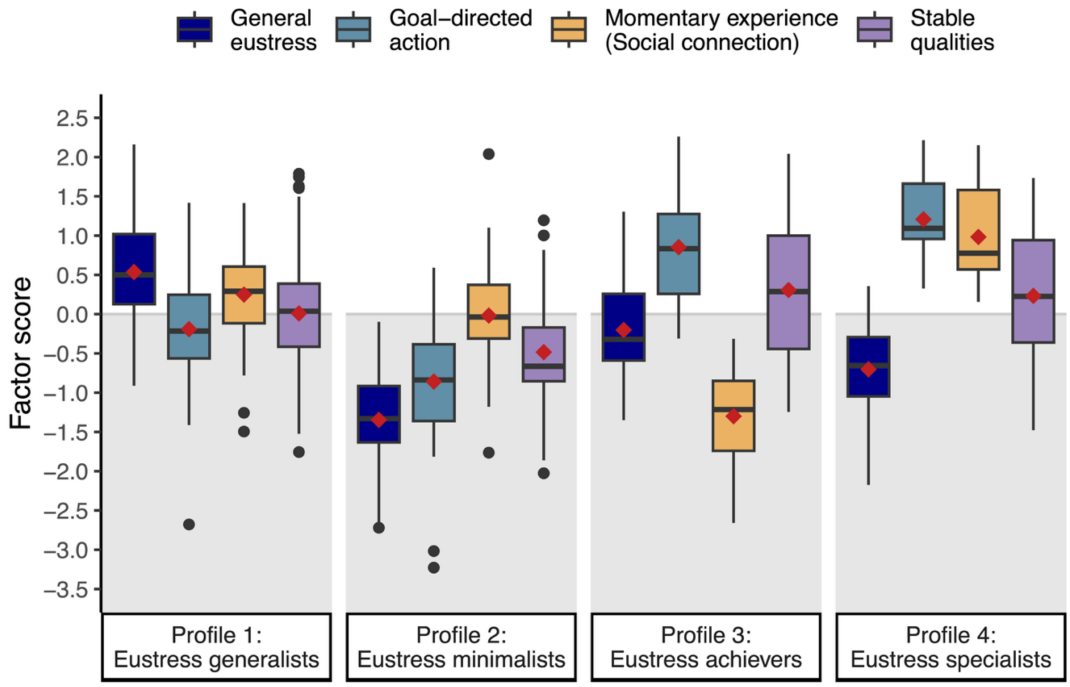
Interestingly, our latent eustress profiles are conceptually similar to profiles from the broaden-and-build theory of positive emotion (Fredrickson & Joiner, 2002). "Eustress generalists" are similar to flourishers who experience high levels of positive momentary engagement and develop positive stable qualities. Vice versa, "eustress minimalists" may reflect languishers who score below average for positive psychological and social functioning and report a lack of resilience when facing difficult situations (Keyes, 2002). Including above-average and below-average scores, "eustress achievers" may be similar to a mixed profile of positive emotion that was established empirically in Winter et al. (2021). Whereas "eustress specialists" may reflect a second mixed eustress profile, the relatively small number of participants fitting this profile ($n = 22$) may also indicate that the model overfitted the data, resulting in a spurious profile (Gerlach et al., 2018). Assessing the validity of this profile in future work would be useful.

Individual differences between profiles

We next investigated associations of the four distinct profiles of eustress with sociodemographic characteristics, personality traits, distress, and wellbeing. To do so, we implemented a multinomial logistic regression model that computed odd ratios (OR) for all entered predictor variables relative to a reference profile. The odd ratios for the reference profile were anchored at 1. For the other profiles, $OR > 1$ suggests an increased relative probability of the predictor compared to the reference profile, whereas $OR < 1$ suggest a decreased relative probability. We chose profile 1 as the reference profile because it represented the largest cluster (152 of 260 participants). As predictors, we included five socio-demographic characteristics (age, gender, education, income, and subjective social status; Adler et al., 2000), six personality dimensions (honesty, emotionality, extraversion, agreeableness, conscientiousness, and openness; Ashton & Lee, 2009), distress (PSS-10; Cohen et al., 1983), and psychological wellbeing (ESS Wellbeing; Huppert & So, 2013). We standardized all predictors except gender, which was entered as a binary variable (male vs. female participants; $n_{gender} = 255$). The lower panel of Figure 3.4 presents the odd

Figure 3.4

Four identified eustress profiles with odd-ratios for various predictors



N	152	42	45	22
Female (%)	44.74	47.61	46.67	81.82
Mean Age (years)	44.85	42.19	46.93	42.68
Age	1	1.27	1.17	0.65
Gender (male)	1	1.04	0.57	**0.10*** **
Education	1	1.60	1.46	0.79
Income	1	1.43	1.01	1.05
Social status	1	0.96	0.98	1.02
Honesty	1	0.86	0.93	1.00
Emotionality	1	1.67	**0.58***	0.84
Extraversion	1	0.52	0.65	1.46
Agreeableness	1	0.83	**0.52*** **	0.89
Conscientiousness	1	0.77	1.38	1.73
Openness	1	**0.51***	1.31	1.46
Distress	1	1.19	0.76	1.09
Wellbeing	1	**0.25*** **	0.49	0.39

Note. Boxplots show standardized factor scores of the four indicator variables summarizing data from all participants assigned to the respective profile. Light gray rectangles distinguish negative values below the average score of the full sample (anchored at zero). The lower panel shows the odd ratios for various predictors, indicating the relative probability of being assigned to a specific profile instead of the reference profile 1 (largest profile). The coefficients depict the change of a one-unit increase in the predictor variable (e.g., one standard deviation) or the change from the reference level to the effect level for categorical variables (e.g., from "female" to "male"). $N = 260$ ($n_{gender} = 255$). Significant odd ratios are bolded and marked with $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

ratios with significance levels extracted from Wald z-tests.

Overall, no single predictor discriminated significantly between individuals across all four clusters. We did, however, observe significant differences between profile 1 (reference profile) and the other three profiles for some predictors. Assignment to profile 2 instead of profile 1 was only half as likely for individuals with increased openness ($OR = 0.51$), and only a quarter as likely for individuals with higher psychological wellbeing ($OR = 0.25$). This suggests that *"eustress minimalists"* may be less open to experiencing challenges as something positive, and that they may have fewer positive experiences in life, especially in non-challenging situations (as assessed for wellbeing). Individuals with higher emotionality ($OR = 0.58$) and higher agreeableness ($OR = 0.52$) were only about half as likely to be assigned to profile 3 compared to profile 1. This suggests that these *"eustress achievers,"* who generate high eustress from goal achievement but little from social connection, often show lower levels of emotionality and lower levels of agreeableness. Finally, male individuals only had 0.10 odds of being assigned as *"eustress specialists"* (profile 4) compared to *"eustress generalists"* (profile 1). This finding suggests that the males in our sample (compared to females) were much more likely to encounter eustress as a general experience instead of as specific kinds of eustress states.

3.5 Discussion

Here we developed the Comprehensive Hierarchical Eustress Review (CHER), the first psychometric instrument to comprehensively assess positive experiences in challenging situations. CHER includes 47 items, divided into three subscales that reflect the 47 low-level features of the CHE model, and implicitly, its three general sources of eustress: goal-directed action, momentary experience, and stable qualities of the individual (Kloidt & Barsalou, 2024). Developing this comprehensive instrument allowed us to investigate the psychometric structure of eustress, quantify relationships with related constructs, and establish groups of individuals with distinct eustress profiles.

3.5.1 RQ1: Unidimensional and multidimensional structure of eustress

In a study with 260 UK participants, a variety of confirmatory factor solutions were examined to establish whether the psychometric structure of eustress is unidimensional, multidimensional, or both. We settled on a bifactor model (M3) as the best-fitting and most conceptually sound solution, indicating that the construct of eustress is weakly multidimensional, consisting of a dominant general factor and several weaker specific (group) factors that reflect CHER's subscales. Out of 47 candidate items, the best performing bi-

factor model retained 35 items from all three subscales that captured the eustress construct meaningfully.

Interestingly, items associated with momentary engagement in CHER's subscale for momentary experience loaded highest on the general eustress factor, together with items for stable qualities (Figure 3.2). Thus, experiencing a high level of general eustress was associated with high levels of momentary engagement along with having stable eustress qualities. The group factors captured additional variance in eustress related to goal-directed action, stable qualities, and social connection (the remaining items for momentary experience). Figure 3.3 captures this overall structure, with 35 items across CHE's three eustress sources forming a tightly integrated core cluster for general eustress, which then differentiates into three closely adjoining regions for the three sources. Because the remaining 12 candidate items were peripheral to the construct, they were excluded from the model, yielding a more coherent measure of eustress that still reflected its theorized structure.

3.5.2 RQ2: Eustress, distress, and wellbeing

The best performing model, M3, not only exhibited satisfactory internal qualities (i.e., test reliability and discriminatory power) but also satisfactory external qualities. Specifically, the general eustress factor showed the expected relationships with distress (negative), another eustress scale (positive), and psychological wellbeing (positive). Notably, eustress and distress were only moderately related, indicating that they are not simple inverses of each other. Whereas eustress and distress may share common underlying demands associated with difficult situations, eustress may differ from distress by emphasizing individuals' coping skills, thereby shifting from threat to challenge appraisals (Lazarus & Folkman, 1987). Additionally, the largest correlation was between general eustress and wellbeing, suggesting that substantial overlap exists between positive experiences in both challenging situations and non-challenging situations (cf. Kloidt & Barsalou, 2024).

3.5.3 RQ3: Clusters of individuals with different eustress profiles

Using the best performing bifactor model, we performed latent profile analysis to establish groups of individuals with different eustress profiles in our sample. We then assessed whether these profiles differed systematically across sociodemographic characteristics, personality traits, distress, and wellbeing. The best-performing solution revealed four profiles that exhibited additional differences across other individual characteristics (e.g., wellbeing, personality traits, gender). Although the extracted eustress profiles conceptually overlapped with typologies for positive emotions (Fredrickson & Joiner, 2002; Keyes, 2002; Winter et al., 2021), future research should assess their robustness across other samples (Gerlach et al., 2018).

3.5.4 Evaluating and refining eustress theory

Establishing the psychometric structure of eustress offers an empirical assessment of existing eustress theories. Most directly, CHER's psychometric structure supports the CHE model of eustress in two ways (Kloidt & Barsalou, 2024). First, the presence of a general eustress factor clearly indicates that positive experiences in challenging situations form a coherent construct of eustress. Second, the further presence of a multidimensional structure supports CHE's proposal that the eustress construct also exhibits a multidimensional character across three sources of eustress: goal-directed action, momentary experience, and stable qualities of the individual. The presence of these latter factors confirms the eustress sources identified in CHE, supporting the CHE model (and the literatures on which it is based).

By establishing the features that constitute eustress generally and each of its sources specifically, CHER's psychometric structure further refines the CHE model. Item loadings in the best-performing bifactor model suggest that the general eustress factor emphasized momentary engagement (i.e., *flourishing / thriving*, *happiness / joy*) and stable qualities (i.e., *optimistic / positive / cheerful*, *wellbeing*, *quality of life*). Additionally, item loadings on the factor for goal-directed action emphasized cognitive processes (i.e., *think / reason effectively*, *perceived control*, *insightful appraisals*); item loadings on the factor for momentary experience emphasized social connection (i.e., *compassion / empathy*, *good relationships*, *sharing*); and item loadings on the factor for stable qualities factor emphasized personal characteristics (i.e., *self-control*, *self-esteem*, *resilience*). Together, these features appear central to constituting positive experiences in challenging situations.

3.5.5 Improving eustress assessments

Determining the psychometric structure of eustress further allowed for an empirical assessment of existing eustress instruments. Most of the previously developed psychometric instruments primarily targeted eustress as the outcome of goal-directed action, failing to measure eustress as an outcome of momentary experience or stable qualities (Cavanaugh et al., 2000; O'Sullivan, 2011; Rodríguez et al., 2013). Assessing CHE's 47 eustress features, however, revealed that items from all sources of eustress reside at the center of the construct. Perhaps most notably, the strongest factor loadings on the general factor were for items from the subscales for momentary experience and stable qualities (*not* from goal-directed action). Ignoring these sources of eustress in psychometric assessment may therefore lead to incomplete or even misleading assessment. Thorough assessments of eustress instead are likely to benefit from a comprehensive set of items, such as the one in CHER that follows from the CHE model.

The results reported here from assessing CHER in a UK-adult sample offer a poten-

tial basis for subscales and items to be included in future eustress assessments. Sampling strongly loading items from the general factor could allow for a straightforward assessment of eustress, similar to general assessments of distress (e.g., PSS-10; Cohen et al., 1983). A general eustress scale also seems useful for capturing important links between eustress, distress, and wellbeing. Conversely, sampling strongly loading items from the specific factors provides the opportunity to assess individual differences and structural relations between the three eustress sources. A multidimensional eustress scale also seems useful for establishing nuanced eustress profiles in a population. Future research could therefore profitably develop and evaluate short versions of CHER that serve a wide variety of research purposes.

3.5.6 Boosting eustress experiences

In addition to the theoretical and empirical contributions that this study makes, it also has potential implications to inform practical applications. For example, we identified four different clusters of individuals who exhibited varying levels of eustress levels, along with correlated patterns of individual difference measures. By using these eustress profiles to inform the selection of interventions, optimal interventions could be tailored to maximizing eustress in particular segments of the population. For example, one eustress profile exhibited a high level of eustress for goal-achievement but not for momentary experience, neither as social connection nor as momentary engagement (*"eustress achievers"*). For these individuals, a focus on developing skills associated with social connection and momentary engagement might be most effective for increasing their overall eustress levels.

More generally, when an individual exhibits a low score for one or more of CHER's subscales, they could receive training to increase the respective source(s) of eustress. For example, eustress that results from goal-directed action could be boosted effectively by training skills that foster successful goal achievement and problem solving, whereas eustress that results from momentary experience could be boosted by strengthening skills associated with savoring and mindfulness, or by strengthening prosocial skills and social connection. Finally, eustress that results from stable qualities could be strengthened by working to establish new eustress habits.

Ultimately, interventions that boost eustress may have desirable spillover effects. As we saw in Table 3.2, higher levels of general eustress were correlated with decreased distress and increased wellbeing. To examine these relationships more carefully, future research could assess whether increasing eustress causally decreases distress (i.e., eustress as an antidote to distress) and causally increases wellbeing (i.e., eustress as an ally to wellbeing). Also of interest is whether increasing wellbeing across all situations causally increases eustress in challenging situations (Kloidt & Barsalou, 2024).

3.5.7 Towards robust population-level inferences

The inferential power of the analyses and results for this project are limited by its non-probabilistic sample design, which does not provide information about the selection probabilities from the adult UK population (Heeringa et al., 2017). Although the basic demographics of our sample approximated adult UK population values, we cannot automatically assume that the results from our measurement models will generalize to other samples or to the general population. Although this project developed a novel eustress instrument that is appropriate for assessing eustress in the general population, the initial evaluation presented here provides insights into a specific sample of UK adults. To establish robust population-level inferences, we therefore invite future research to replicate and extend our analyses with probabilistic sampling methods.

3.6 Conclusion

The Comprehensive Hierarchical Eustress Review (CHER) developed and presented here is the first psychometric instrument to comprehensively assess positive experiences in challenging situations, while providing psychometric evidence of its quality. Determining the psychometric structure of eustress as measured with CHER further supported and refined the CHE model of eustress. Quantifying relationships with related constructs highlighted how promoting eustress may be related to increased wellbeing and decreased distress. The results with CHER also offer an initial basis for measuring general eustress comprehensively in an adult UK sample, along with its three specific sources of goal-directed action, momentary experience, and stable qualities. Finally, identifying clusters of individuals with distinct eustress profiles can support the design of specific eustress interventions for different kinds of individuals.

Chapter 4

Establishing feature profiles of threatening and challenging situations generated with AI

This chapter is an exact copy of the following publication:

Kloidt, J., Balaya, M., & Barsalou, L. W. (2025). *Establishing feature profiles of threatening and challenging situations generated with AI.* PsyArxiv. https://doi.org/10.31234/osf.io/g4m7u_v1

This study was preregistered at: https://osf.io/8bpcj/

We have uploaded supplemental materials to the Open Science Framework including raw data, analysis files, and supplemental results files. They can all be accessed here: https://osf.io/5x8gh/

4.1 Abstract

A variety of difficult situations can elicit stress responses, yet little research has systematically characterized the features that make situations threatening and challenging. In a preregistered study, we developed a normed set of situations and established features associated with threat and challenge. Using an open-source large language model (LLM), we first generated 20 situations that represent common stressors for UK adults (e.g., "Give a public speech in front of a large audience"). We then asked 81 UK adults to evaluate each situation on dimensions of threat, challenge and eight theory-derived features (e.g., intrinsic difficulty), aggregating their judgments into a 10-dimensional feature profile for each situation. We also tested whether an open-source LLM could reproduce human feature profiles and feature relationships. In the human data, we observed highly reliable feature profiles for the situations that exhibited low threat and moderate challenge overall, while varying reasonably. The eight features were surprisingly similar in how they correlated with threat and challenge (as opposed to exhibiting inverse patterns), explaining high variance in each. Unsupervised clustering identified four coherent groups of situations that illustrate different ways threat and challenge can manifest in daily life. Although LLM judgments approximated human judgments at the aggregate level, their accuracy varied substantially across situations and measures such that LLM judgments failed to capture structural relationships observed in the human data. These findings advance our understanding of situational features underlying threat and challenge, while illustrating the potential and current limitations of LLMs as tools for psychological research.

4.2 Introduction

Hans Selye's seminal definition of stress as an organism's non-specific response to demanding circumstances has provided the conceptual foundation for decades of subsequent research (O'Connor et al., 2021; Schneiderman et al., 2005; Selye, 1936). Recognizing that not all stress responses are equal, Selye later introduced the distinction between maladaptive distress and adaptive eustress (Selye, 1974; Szabo et al., 2012). Whereas distress has been extensively documented as detrimental to health, wellbeing, and performance (Epel et al., 2018; McEwen, 1998; O'Connor et al., 2021), eustress has only been investigated more recently, with emerging evidence delineating its underlying cognitive, affective, and behavioral mechanisms (Kloidt & Barsalou, 2024, 2026; Simmons et al., 2024). An equally important insight from Selye's research was the principle of non-specificity, namely that a wide variety of difficult situations (stressors) can elicit stress responses (Selye, 1936; Szabo et al., 2012). Although some research has attempted to catalogue stressful life events (e.g., Almeida et al., 2002; Holmes & Rahe, 1967; Slavich & Shields, 2018), comparatively little work has sought to systematically characterize the features that make a situation stressful in the first place.

4.2.1 Importance of situations in stress research

A well-evidenced body of literature demonstrates that individual behaviors, such as stress responses, are surprisingly variable across contexts (Bandura, 1978; Cervone et al., 2001; Funder, 2016; Mischel & Shoda, 1995). For instance, managing a pressing work deadline is very stressful to most people, whereas relaxing at home may not be stressful at all. In other words, individuals show substantial situational variability in their responses rather than exhibiting a stable, uniform, trait-level of stress that most traditional stress instruments aim to measure (e.g., Cohen et al., 1983). Moreover, these patterns of situational variability are themselves individualized: People differ not only in the overall magnitude of stress they experience but also in the specific ways their responses fluctuate across situations, reflecting robust individual by situation interactions (Dutriaux et al., 2023): Different individuals respond to the same situation in different ways. It follows that accurate assessments of stress in real-world contexts should incorporate (or at least be aware of) the underlying situations rather than ignoring or averaging across them. Systematically characterizing the features of such situations is therefore essential, both for advancing theoretical understanding and for identifying real-world contexts for applied interventions designed to mitigate distress and/or foster eustress.

4.2.2 Theoretical perspectives on the features of difficult situations

To advance beyond catalogues of stressful events, it is necessary to identify features that distinguish between different types of difficult situations. Two influential frameworks that characterize stressors are the biopsychosocial model of challenge and threat (Blascovich et al., 2000; Blascovich & Mendes, 2010) and the transactional model of stress (Lazarus & Folkman, 1984). Similar to Selye's distinction of stress responses into maladaptive distress and adaptive eustress, both models organize difficult situations into threats and challenges, but they emphasize this distinction differently.

The biopsychosocial model locates the distinction between threats and challenges in the structural properties of situations (Blascovich et al., 2000; Blascovich & Mendes, 2010). In motivated performance contexts, individuals appraise a situation as threatening when demands exceed resources or as challenging when resources meet or exceed demands. In the biopsychosocial model, situational demands (e.g., intrinsic difficulty, time and effort) and available resources (e.g., skills, control, awareness of an obvious solution) are the core features that determine whether a situation is experienced as threatening or challenging.

In contrast, the transactional model of stress emphasizes dynamic interactions between the individual and their immediate environment (Lazarus & Folkman, 1984). Situations are appraised as threats when they have the potential for producing loss or damage to an individual, or as challenges when they have the potential for producing gain or reward. Notably, the appraisal of a difficult situation as a threat or challenge also depends on the individuals' ability to cope with the situation effectively. As a result, perceived relevance (anticipated loss, anticipated gain) and coping ability are the core features of threats and challenges in the transactional model.

Importantly, the biopsychosocial model and the transactional model propose that threatening and challenging situations exhibit different types of features (cf. Jamieson, 2017). Some of these features can largely be intrinsic to a situation, whereas others can reflect what a situation affords for a specific individual, with these affordances varying widely across different individuals. For example, some situations are intrinsically difficult because they are associated with intractable problems (e.g., a terminal illness) or require inordinate resources (e.g., defending oneself against a major lawsuit). In contrast, other situations are difficult because of the limited resources that individuals bring to them, such as insufficient training, low resilience, poor self-regulation, or short patience. Other individuals with greater resources might not find the same situations difficult.

4.2.3 Practical approach to measuring the features of threats and challenges

Building on both theoretical perspectives, the present study adopts a practical approach to characterizing the features of threatening and challenging situations. Specifically, we aimed to develop a normed set of situations that systematically vary in the types and intensities of threat and challenge they elicit. From an initially broad pool of candidate situations, we selected a smaller subset for closer empirical evaluation, with the aim of identifying the features that distinguish threats from challenges and generalizing these features across situations. Unlike inventories of stressful life events that primarily catalogue the occurrence of situations, we focused on systematically characterizing the underlying features that make situations threatening and/or challenging. This norming approach provides a foundation for establishing reliable situational exemplars that can be used in subsequent research to probe stress responses in controlled yet ecologically valid ways. Better understanding these features could also be useful in clinical contexts to better understand why some situations induce threat and challenge. To construct and refine this set of situations, we leveraged recent advances in large language models (LLMs) that were integrated centrally into this project's workflow, as described later.

It's important to note from the start that this study will be focusing on individual situations and not on individual people. Rather than measuring threat and challenge as traits of individuals, we will be measuring them as features of situations. Again, these features may often reflect different affordances that different people experience in the same situation, but our interest here will be in the central tendency of these affordances, viewing them as general features of situations, statistically speaking.

4.2.4 Large language models (LLMs) in psychological research

LLMs are transformer-based machine learning systems trained on enormous amounts of data to produce or analyze meaningful linguistic and multimodal informational patterns (Demszky et al., 2023). LLMs can increase the speed and scale of empirical research by quickly generating and re-generating survey items (Rothschild et al., 2024), imitating collective knowledge to predict human judgments (Hewitt et al., 2025), and reducing cost and reliance on human labor by simulating study participants (Argyle et al., 2023; J. S. Park et al., 2024). Integrating LLMs into the research process, however, poses practical and ethical barriers, including limited transparency, accessibility, and validity (Agnew et al., 2024; Hussain et al., 2024). To mitigate these issues and adhere with principles of open science, we developed an augmented workflow that kept researchers in the loop and used an open-source LLM for accessible and reproducible analyses.

Generating situations associated with threat and challenge

To establish the features of threatening and challenging situations, we first used an LLM to generate a large set of candidate situations. We then reviewed and refined the pool of candidate situations to produce a final set of 20 situations that offered comprehensive coverage of the threat–challenge space while remaining concise enough for empirical investigation. The aim was to represent threats and challenges systematically, capturing different intensities and combinations of both constructs across diverse life domains (Zayas et al., 2008). Existing stress inventories tend to oversample rare but highly stressful events, thereby limiting variance and ecological representativeness (Almeida et al., 2002; Holmes & Rahe, 1967; Slavich & Shields, 2018). When prompted appropriately, LLMs, in contrast, can rapidly generate large and diverse sets of candidate situations that vary systematically in both frequency and intensity, ensuring a representative distribution of situational features.

The situations developed should further reflect the experiences of UK adults who were our target population for norming these situations. Traditional norming studies risk producing idiosyncratic sets of situations that capture only the experiences of individual participants, whereas expert-led approaches can inadvertently introduce bias based on the perspectives of a small group of researchers (Smith & Noble, 2025). LLMs, in contrast, can approximate collective experiences by aggregating information from their large and diverse training data, thereby producing situations that likely resonate with the everyday experiences of many UK adults. Nevertheless, this approach is not without limitations: The representativeness of generated situations is constrained by the composition of the training data, which may underrepresent the experiences of specific populations (Grossmann et al., 2023). To evaluate our set of situations, we subjected them to empirical norming, both to validate the 20 situations as representative exemplars of threat and challenge, and to derive generalizable insights into the features that characterize this general kind of situation.

Establishing the features of threatening and challenging situations

To establish the critical features for the final set of 20 difficult situations, we asked UK adults to evaluate each situation on dimensions of threat, challenge, and eight theoretically derived features. Five of these features were based on the biopsychosocial model of challenge and threat (i.e., intrinsic difficulty, time and effort, skills and resources, control, solution obviousness; Blascovich et al., 2000). The remaining three features were drawn from the transactional model of stress (i.e., anticipated loss, anticipated gain, coping ability; Lazarus & Folkman, 1984). For each situation, we averaged the participants' judgments for each of the 10 features to create a 10-dimensional vector that constituted the situation's feature profile. Of interest was establishing the levels of these features in

threatening and challenging situations, along with how well these features predict threat and challenge.

Another aim of this study was to assess whether LLMs could approximate the feature profiles obtained from our human participants. We examined the extent to which LLM-generated feature profiles converged with human feature profiles, both in terms of reproducing the average judgments and in capturing the structural relationships among features. Demonstrating such convergence would indicate that LLMs are not only capable of simulating human evaluations of threatening and challenging situations but also of generating meaningful insights into the psychological dimensions that distinguish them.

4.2.5 Study overview

This study had three primary aims. The first aim was to develop a comprehensive and balanced set of real-life situations that reliably represent threat and challenge in UK adults. To do so, we implemented an LLM-augmented process to generate, select, and review a set of diverse real-life situations that represent different types and intensities of threat and challenge. For each situation, we collected average threat and challenge judgments across 81 UK adults and tested the stability of these average judgments. Of interest was whether the average threat and challenge could be viewed as reliable and stable features of a situation (analogous to how neuroticism and agreeableness can be viewed as reliable and stable features of an individual).

The second aim was to establish the feature profile associated with each of these 20 situations, and more generally, across the situations. How do these profiles vary across situations and form clusters of related situations? Across situations, what features tend to show the highest and lowest values? Additionally, how well do these features predict threat and challenge? As threats and challenges increase, what situational features increase as well, or decrease? To address this aim, we collected judgments for the following theoretically derived features related to handling stressors: intrinsic difficulty, time and effort, skills and resources, control, solution obviousness, anticipated gain, anticipated loss, and coping ability (Blascovich et al., 2000; Lazarus & Folkman, 1984).

The third aim of this study was to investigate whether an open-source LLM can generate feature profiles for each situation, similar to the profiles that human participants produce. Specifically, we asked the LLM to make the same judgments as the human participants about threat and challenge for each of the 20 situations, and also for the eight features. Of interest was whether the LLM generated the same average values of the 10 measures for each situation as the human participants, and whether the LLM produced the same pattern of correlations between measures.

This study was preregistered on the Open Science Framework (https://osf.io/8bpcj). Again, our preregistered hypotheses focused on challenges and threats as features of situ-

ations, not as traits of individuals. We note, however, that our study design is not individual agnostic, given that the situations are tailored to our target population, and that the situations' feature profiles are based on the averaged judgments of our participants. Below, we present the main preregistered hypotheses. We also preregistered additional minor hypotheses that are not addressed in the main text but that are addressed in the Supplemental Materials, which can be found here: https://osf.io/5x8gh/

Hypothesis 1a: Large differences between situations

We expected that the 20 situations would vary from low to high in threat and challenge, with the mean judgments (across individuals) ranging over at least half their 10-point scales, from 2.5 to 7.5.

Hypothesis 1b: Reliable and stable judgments across situations

We expected that the situational differences on the 10 measures in the feature profiles (averaged across individuals) would be highly reliable, such that the ordering of situations by threat and challenge is likely to be stable on future occasions (Cronbach's alpha, $ICC3k > .80$ for both). Because the stability of the measures underlying the feature profiles was of most importance here—not their saturation—coefficient alpha was used instead of coefficient omega (Dutriaux et al., 2023).

Hypothesis 2a: High construct validity across situations

We expected that the eight features would predict threat and challenge judgments across situations. As a situation became more threatening, we expected it to also become more intrinsically difficult and requiring more time and effort so that individuals would anticipate increasing losses. Additionally, as a situation became more threatening, we also expected it to offer less skills and resources, less control, and a less obvious solution so that individuals would anticipate lower gains and be less able to cope with the situation. We expected all these correlations to be large, $> |.30|$, applying the definition of a large effect size from Funder and Ozer (2019) and Gignac and Szodorai (2016).

For challenge, we expected it to correlate positively with all predictors (again, with all correlations being large, $> .30$). Given that challenges are also stressors, we expected challenge to positively correlate with intrinsic difficulty, time and effort, and anticipated loss. We however expected that challenges would differ from threats in their relations with the remaining five features. Because a challenge is a situation where resources meet or exceed demands (Blascovich et al., 2000), we expected positive correlations with skills and resources, control, and solution obviousness. Since a challenge emerges from transactions where the individual appraises a situation as potentially rewarding and possible

to manage effectively (Lazarus & Folkman, 1984), we also expected positive correlations with anticipated gains and coping ability.

Hypothesis 2b: High content validity across situations

In addition to large correlations, we also expected that the eight features, when combined, would explain high amounts of variance ($> 50\%$) in threat and challenge across situations. In other words, we expected that these eight features of the 20 situations would explain the threat and challenge experienced in them comprehensively.

Hypothesis 2c: Meaningful clusters of situations

We expected that the 20 situations could be organized into meaningful clusters of related situations based on their similarity across the 10-dimensional feature profiles (using hierarchical agglomerative clustering). To establish the best clustering model, we considered solutions with two to five clusters and used dendrogram inspection and silhouette coefficients to establish the strongest solution (with values closer to $+1$ indicating distinct clusters; Rousseeuw, 1987).

Hypothesis 3: Predicting features profiles with an LLM

We expected that the LLM, when asked to evaluate the 10 measures across the 20 situations, would produce a similar pattern of results observed in the human participants. We expected that the LLM's averaged judgments (across situations) for the 10 measures would exhibit small-to-moderate deviations from the human averaged judgments for the 10 measures. Specifically, we predicted that the absolute differences between simulated and actual judgments (error) and the signed differences between simulated and actual judgments (bias) would be $\leq |2.5|$ on our 10-point scales so that LLM versus human judgments both belonged to the same scale label presented every 2.5 points (e.g., "moderately challenging").

We further predicted that, for each measure, the 20 LLM judgments from the 20 situations would exhibit large positive correlations with the 20 human judgments from the 20 situations ($> .30$; cf. Funder & Ozer, 2019; Gignac & Szodorai, 2016). For example, we predicted that as human challenge judgments increase across situations, LLM challenge judgments would also increase.

Discovery: Predicting structural relationships with an LLM

In two discovery analyses, we investigated whether the LLM could simulate structural relations between measures that were present in the feature profiles from our human participants. To do so, we compared pairwise correlations from human feature profiles

with pairwise correlations from the LLM-generated feature profiles. We further explored whether features in the LLM feature profiles could explain variance in challenge and threat for the human feature profiles.

4.3 Methods

4.3.1 Design

This study was part of a larger project that collected data for two related studies on threat and challenge in real-life situations. In a multi-level design, 81 participants judged the same 20 situations for threat and challenge (dependent variables), and eight potentially related features. To establish the critical measures used across analyses, we averaged participant judgments to create a 10-dimensional feature profile for each situation (i.e., threat, challenge, and the eight features). We also prompted an open-source LLM to generate feature profiles for the same 20 situations and the same 10 measures.

4.3.2 Participants

Ethics for this study was approved by the College of Medical, Veterinary, and Life Sciences Ethics Committee at the University of Glasgow (application no. 200240282). We recruited a sex-balanced sample of UK residents, aged 18 to 80 years old, with self-reported English fluency, and at least 20 completed studies with a 100% approval rating on the Prolific online platform. To ensure that our results would characterize the situations as reliably as possible, we collected the largest sample we could based on our financial resources for the project. As we will demonstrate, all data exhibit high levels of reliability. Our preregistered data exclusion checks flagged two participants for potential mechanical responding. Upon inspection, we decided against excluding them because their data exhibited systematic variability likely to result from responsible performance.

Our final sample included 81 UK adults (42 men, 39 women) with a mean age of 43.22 years (SD = 15.04). Participants most commonly reported an annual income between £20,001 and £30,000 (30.86%), thereby approximating the UK population average (Office for National Statistics, 2025). Most participants (71.60%) reported more than 13 years of formal education, exceeding the population average of equivalent Level 4 qualifications (i.e., at least one year of higher education/ university; Office for National Statistics, 2021). On a 10-rung ladder, participants reported a median subjective social status of 6 (range = 2–8), suggesting that they viewed themselves at a similar social standing compared to other UK adults (Adler et al., 2000).

4.3.3 Large Language Model (LLM)

We used the comparatively small, open-source LLM "Meta-Llama-3-8B-Instruct", a Llama 3 instruction-tuned model optimized for dialogue use, containing 8.03B parameters and trained on publicly available online data (March 2023 cut-off; AI@Meta, 2024). We accessed the LLM via the Hugging Face online hub (huggingface.co/docs/hub) and implemented Hugging Face's Python libraries (huggingface.co/docs) for applying the model to two specific tasks: generating challenging and threatening situations and generating feature profiles for these situations.

4.3.4 Materials

Threatening and challenging situations

We employed a three-step LLM-augmented workflow to develop 20 real-life situations from a UK context that comprehensively cover different types and intensities of threat and challenge. We briefly outline each step below and provide a reproducible workflow in the Supplemental Materials (SM-1).

In the first step, we prompted "Meta-Llama-3-8B-Instruct" to generate 60 systematically differing candidate situations. We set the model's temperature to zero for deterministic output and varied the prompts to retrieve diverse situations. Specifically, we developed five prompts, each focusing on a different type of situational requirement (reflecting the *combination* of demands, difficulty, resources, control, solution obviousness). For each prompt, the LLM generated 12 situations, representing a unique combination of [low, medium, high] requirements × [low, high] anticipated loss × [low, high] anticipated gain. Low levels of requirements, loss, and gain were included because they may still elicit some levels of threat and challenge, thereby helping capture the constructs comprehensively. Widely varying levels further ensured an unrestricted range of variance, important for evaluating relations between measures.

In the second step, we selected a subset of 20 final situations from the initial 60 candidate situations, which, together, covered diverse areas of life (e.g., work, housing, relationships) and varied systematically according to the parameter combinations used to generate them. We included four situations that were generated to reflect low requirements and eight situations each reflecting medium and high requirements. We favored medium and high requirements as they are most likely to induce threat and challenge (Blascovich et al., 2000). We further ensured that the 20 situations reflected all possible combinations of loss and gain evenly.

In the last step, we performed minor edits on 15 of 20 situations. We simplified situations to improve clarity, added context and/or details to reduce ambiguity, and changed the mode of action so that the situation described an evolving process rather than a single

timepoint. Table 4.1 presents the final set of 20 situations used in this project. Please see SM-1 for a list of all 60 candidate situations.

Table 4.1

The 20 final situations

		Requirement			
Identifier	**Situation**	**Type**	**Level**	**Loss**	**Gain**
S01*–Decent signal	Try to find a decent Wi-Fi signal at a coffee shop.	resources	L	L	L
S02–Hidden talent	Discover a hidden talent for photography and start sharing your work online.	solution	L	L	H
S03–Long queue	Get stuck in a long queue at the post office.	control	L	H	L
S04–No GPS	Try to navigate a new city without a map or GPS.	resources	L	H	H
S05*–New recipe	Try to cook a new recipe with many steps for the first time.	difficulty	M	L	L
S06–Squeaky door	Try to fix a stubborn squeaky door in your flat.	solution	M	L	L
S07*–Surprise visit	Handle a surprise visit from an old friend gracefully.	demands	M	L	H
S08*–Dream job	Start the process of finding and getting your dream job.	solution	M	L	H
S09*–Parking fine	Deal with a parking fine for overstaying in a parking spot.	difficulty	M	H	L
S10*–Customer service	Deal with a difficult customer service representative.	control	M	H	L
S11*–Social media	Try to break free from your social media habits to focus on your mental health.	resources	M	H	H
S12*–Surprise party	Plan a surprise party for a loved one.	solution	M	H	H
S13*–Car accident	Handle the consequences of a minor car accident.	demands	H	L	L
S14*–Train schedule	Navigate a complex train schedule to get to a meeting on time.	solution	H	L	L

(continued on next page)

Table 4.1 (continued)

		Requirement			
Identifier	**Situation**	**Type**	**Level**	**Loss**	**Gain**
S15*–Work deal	Try to close a big deal at work and receive a significant bonus.	control	H	L	H
S16*–Promotion	Taking on new responsibilities after receiving a promotion.	solution	H	L	H
S17*–Beloved pet	Saying goodbye to a beloved pet about to be put to sleep.	difficulty	H	H	L
S18–Family argument	Get into a heated argument with a family member over a sensitive topic.	control	H	H	L
S19*–Public speech	Give a public speech in front of a large audience.	demands	H	H	H
S20*–Marathon training	Develop and successfully execute a training plan to run your first marathon.	control	H	H	H

Note. Situations were generated using a three-step LLM-augmented process. Situation identifiers with asterisk distinguish situations that were edited by the researchers to increase clarity and detail. Requirements show the type (demands, difficulty, resources, control, solution obviousness) and level (low, medium, high) that the situations were designed for. We reverse-coded levels for resources, control, and solution obviousness so that, for instance, a situation that is uncontrollable would be categorized as a high requirement. Solution = solution obviousness; L = low; M = medium; H = high

Situated judgment scales

To collect situation-specific judgments of threat, challenge, and their eight related features, we asked participants to evaluate the 20 situations in Table 4.1 on the 10 judgment scales presented in Table 4.2 (cf. Dutriaux et al., 2023). In addition to threat and challenge, we included eight features that reflected the biopsychosocial model (i.e., intrinsic difficulty, time and effort, skills and resources, control, solution obviousness; Blascovich et al., 2000) and the transactional model (i.e., anticipated loss, anticipated gain, coping ability; Lazarus & Folkman, 1984). Because the features from the biopsychosocial model focused on characteristics inherent to the situation, participants were asked to judge the situations in general. Because threat, challenge, and the features from the transactional model targeted characteristics of the situation that can vary across individuals, participants were asked to judge their personal experiences. These differences in wording can be seen in the queries presented for the 10 measures in Table 4.2.

Table 4.2

Measures with situation-level descriptives and reliability

Measure	*M (SD)*	*ICC3k*
Threat (DV)		
When in this situation, how threatened would you feel?	2.50 (2.70)	.97
Challenge (DV)		
When in this situation, how challenged would you feel?	5.75 (2.92)	.98
Intrinsic difficulty		
How intrinsically difficult is this situation in and of itself, independent of the person in it, regardless of their coping skills and resources?	5.02 (2.92)	.99
Time and effort		
How much time and effort does it typically take for people to handle this situation effectively?	5.93 (2.71)	.99
Skills and resources		
How much do people have the skills and other resources typically required to handle this situation effectively?	6.15 (2.41)	.77
Control		
How much control do people typically have over this situation relative to other factors?	5.64 (2.69)	.97
Solution obviousness		
When people are in this situation, how obvious is a solution or plan for handling it effectively?	6.52 (2.39)	.96
Anticipated loss		
When this situation occurs, how much loss would you anticipate experiencing across all the relevant areas of your life?	2.89 (2.71)	.99
Anticipated gain		
When this situation occurs, how much gain would you anticipate experiencing across all the relevant areas of your life?	5.46 (3.27)	.99
Coping ability		
When this situation occurs, how effectively would you be able to cope with it?	6.48 (2.68)	.97

Note. The first two measures are the dependent variables (threat, challenge) followed by the eight features. The name of each measure (bold) is followed by the item. All measures were rated on continuous 0 to 10 scales (one decimal point precision). Scale labels for threat, challenge, and coping ability were "not at all" (0), "a little" (2.5), "moderately" (5), "a lot" (7.5), and "extremely" (10). For all other measures, scale labels were the same except "moderate" (5) and "extreme" (10). The *ICC3k* is Cronbach's alpha for the overall score of each measure, capturing the measures' test reliability and stability in ordering situations. M = mean; SD = standard deviation. $N = 81$

In addition to collecting data from our human participants, we instructed the LLM, "Meta-Llama-3-8B-Instruct," to predict each situation's 10-dimensional feature profile (see SM-2 for a reproducible workflow). We prompted the LLM to evaluate the 20 situations in a fixed order (see Table 4.1) for one judgment scale at a time (also in fixed order, see Table 4.2). We removed randomization and blocking to avoid confounding effects reported in LLM simulations with blinded designs (Gui & Toubia, 2023). We changed personal pronouns in the judgment scales to instead reflect UK adults, not an individual participant (e.g., "When in this situation, how challenged would UK adults feel on average"?) and instructed the LLM to generate numerical judgments ranging from 0 to 10 (with one decimal point precision). In contrast to generating situations with the LLM that used a deterministic setting (temperature = 0.0), we now used the LLM's default settings (including temperature = 1.0) to generate somewhat variable judgments stochastically. We repeated LLM data collection 50 times to compute stable estimates. Out of the 10,000 judgments collected, we removed 23 that were outside the required scale ranges. SM-3 reports robustness analyses that explore the impact of the temperature parameter on LLM responses.

4.3.5 Analysis

We performed statistical analyses in R (v4.3.2; R Core Team, 2023) with the packages tidyverse (Wickham et al., 2019), psych (Revelle, 2024), and factoextra (Kassambara & Mundt, 2020). We have uploaded all relevant materials to the Open Science Framework, including the raw data, analysis scripts, and the supplemental results mentioned throughout. All can be accessed here: https://osf.io/5x8gh/

4.4 Results

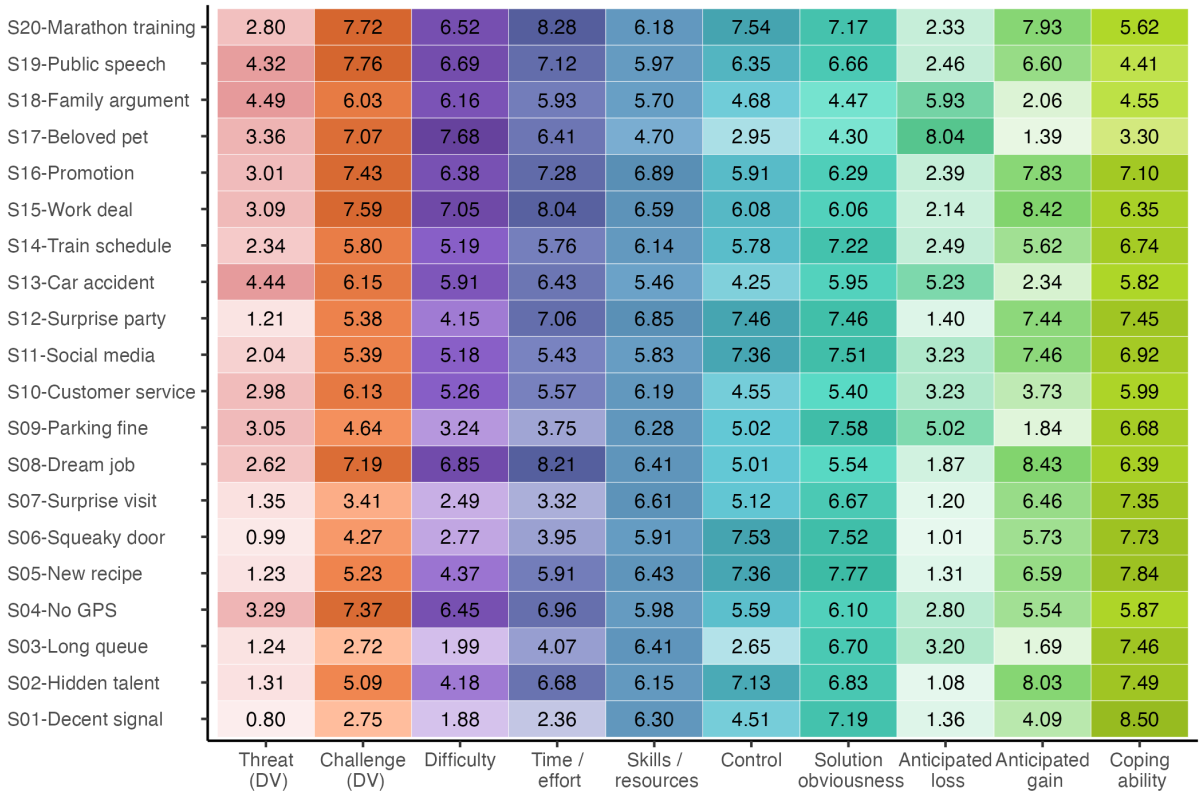
4.4.1 Hypothesis 1a and 1b: Situations differed moderately but reliably

We predicted that the 20 situations assessed would show large differences in threat and challenge. Table 4.2 presents the grand means for threat, challenge, and their eight potentially associated features. Each row of Figure 4.1 presents a single situation's feature profile across the 10 measures in the original scale values (i.e., the mean judgment for each measure across participants). The situations' grand mean for threat was small ($M = 2.50$; $SD = 2.70$), ranging from 0.80 (S01-Decent signal) to 4.49 (S18-Family argument). The situations' grand mean for challenge was moderate ($M = 5.75$; $SD = 2.92$), ranging from 2.72 (S03-Long queue) to 7.76 (S19-Public speech). Although challenge judgments covered

more than 50% of the judgment scale, neither threat nor challenge judgments covered the specific range that Hypothesis 1a predicted (2.5 to 7.5).

Figure 4.1

Feature profiles of the 20 situations



Note. Each row of the heatmap presents a 10-dimensional feature profile for a situation in Table 4.1. The index below each column indicates the corresponding measure in Table 4.2. Each cell presents a situation's mean judgment for a specific measure across participants. As a cell becomes more saturated, the mean judgment across participants increasingly approached 10 (on a 0 – 10 scale; Table 4.2). As a cell becomes increasingly white, the mean judgment across participants increasingly approached 0. Please see SM-4 for further situation-level descriptives. $N = 81$

The columns in Figure 4.1 further illustrate that judgments for intrinsic difficulty, time and effort, control, anticipated loss, anticipated gain, and coping ability varied substantially across the 20 situations, whereas judgments for skills and resources and for solution obviousness showed little variance. Differences between situations were perhaps most pronounced for anticipated loss and anticipated gain, reflecting the original loss-gain combinations used to generate the situations (see Table 4.1). Conversely, the rows in Figure 4.1 illustrate that the 10-dimensional feature profiles for the 20 situations exhibited different combinations of high versus low judgments, suggesting that the situations covered the different types and intensities of difficult situations comprehensively.

We further predicted that the differences between the situations' feature profiles in

Figure 4.1 would be highly reliable across individuals. As predicted, Table 4.2 shows that the situations' mean judgments were highly stable across individuals for threat (*ICC3k* = .97), challenge (*ICC3k* = .98), and all eight features (range = .77–.99). These results suggest that if a similar UK sample were to assess the feature profiles for these situations in the future, the new sample would produce essentially the same feature profiles.

Individual participant results

By aggregating our multi-level data into feature profiles for situations, we removed individual-level variance from the dataset, along with individual by situation interactions. Nevertheless, it's important to note that large individual differences existed in threat, challenge, and their eight associated features, along with a large individual by situation interaction for each measure. For the interested reader, we provide descriptive analyses of individual differences in SM-5 and individual by situation interactions in SM-6. As predicted in another preregistered hypothesis, a large individual by situation interaction occurred for each of the 10 measures, indicated by low agreement between situations in ordering participants by threat (*ICC2* = .35), challenge (*ICC2* = .18), and the eight associated features (range = .08–.21). These low levels of agreement show that different situations did not rank order the 81 individuals in the same way for each measure but organized them quite differently. Because of our interest in establishing feature profiles for the 20 threatening and challenging situations, we do not report results at the participant level further. Instead, all later analyses focus on and use the 10-measure feature profiles for the 20 situations plotted in Figure 4.1.

4.4.2 Hypothesis 2a: Features exhibited mixed construct validity

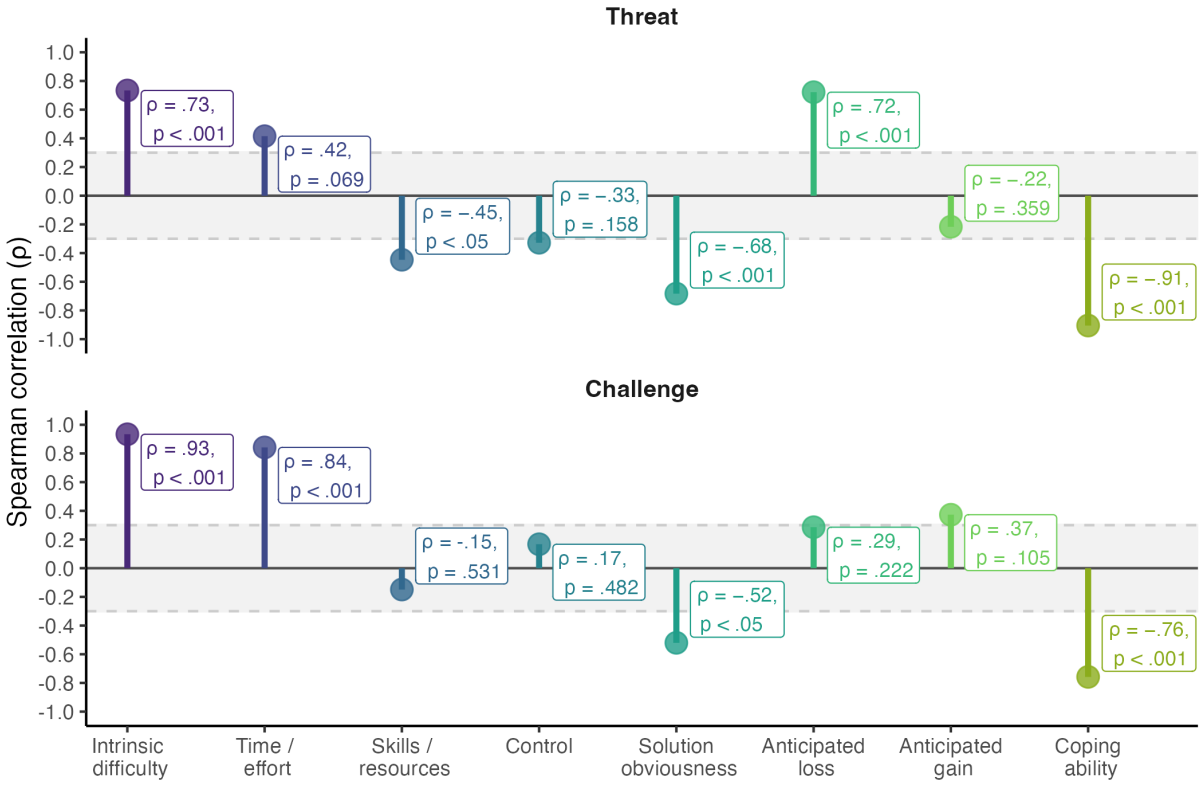
We expected that the eight features would predict threat and challenge across situations, indicated by large correlation coefficients $> |.30|$ (cf. Funder & Ozer, 2019; Gignac & Szodorai, 2016). Following our preregistered assumption checks, we computed Spearman correlations for threat with each feature and for challenge with each feature. In contrast to the preregistered analysis, we computed the correlations on the feature profile data in Figure 4.1 instead of on the raw data, thereby removing extraneous and potentially biasing sources of variance associated with individuals and individual by situation interactions. Whereas the originally proposed analysis does not test Hypothesis 2a correctly, the analysis reported here does. Please see SM-7 for a detailed discussion.

Figure 4.2 shows that, in contrast to our hypothesis, only about half the features showed large significant correlations with threat and challenge, although most correlations were in the expected directions. For threat (upper panel), all pairwise correlations were in the expected direction. Intrinsic difficulty and anticipated loss exhibited significant correla-

tions > .30, whereas time and effort exhibited a non-significant positive correlation. Skills and resources, solution obviousness, and coping ability exhibited predicted significant negative correlations > |.30|, whereas control and anticipated gain exhibited non-significant correlations in the predicted negative direction.

Figure 4.2

Spearman correlations between dependent variables and features



Note. Pairwise Spearman correlations between features and threat (upper panel) or challenge (lower panel). The dashed y-intercepts depict the cut-offs for a large correlation ($\rho = |.30|$; cf. Funder & Ozer, 2019; Gignac & Szodorai, 2016), the gray rectangle with dashed intercepts distinguishes correlations below the cut-off. One-sided confirmatory significance testing established whether correlations were significantly different from zero. $N = 81$

For challenge (lower panel), intrinsic difficulty and time and effort exhibited predicted significant correlations > .30, whereas control, anticipated loss, and anticipated gain exhibited non-significant positive correlations in the predicted direction. In contrast to our predictions, we observed negative correlations of challenge with skills and resources, solution obviousness, and coping ability. Skills and resources exhibited a non-significant negative correlation, whereas solution obviousness and coping ability exhibited negative correlations that were large and significant.

Because Spearman correlations assess monotonic associations between variables, a non-significant result does not necessarily imply the absence of any relationship, but rather

the absence of a consistent monotonic trend. More complex or non-monotonic patterns may still exist but cannot be captured by this coefficient. With only 20 situations, our data did not permit robust testing of such nonlinear dynamics. To evaluate the stability of our findings, we however computed Kendall's rank correlations, producing essentially the same pattern of results (see SM-8).

Overall, Figure 4.2 shows similar correlational patterns for threat and challenge, when partial inverses were expected. As a situation became more threatening, it was perceived as increasingly difficult, with higher potential for loss and a less obvious solution, fewer available skills and resources, and lower potential to cope. As a situation became more challenging, it was similarly perceived as increasingly difficult, more effortful, with a less obvious solution, and lower potential to cope. Differences between threat and challenge appeared most pronounced for time and effort (unrelated to threat but positively related to challenge), skills and resources (negatively related to threat but unrelated to challenge), and anticipated loss (positively related to threat but unrelated to challenge).

4.4.3 Hypothesis 2b: Feature profiles exhibited excellent content validity

We further predicted that the eight features combined would explain more than 50% of variance in threat and challenge across situations. Again, we adjusted our preregistered analysis plan to compute regressions on the feature profiles instead of the raw data, resulting in two group-level linear regressions predicting threat and challenge, respectively (see SM-7 for further details).

Our first regression indicated that the eight features predicted threat significantly and highly ($F(8,11) = 6.99$, $p < .01$, $f^2 = 2.52$), accounting for 71.62% of variance. Our second regression indicated that the eight features also predicted challenge significantly and highly ($F(8,11) = 66.25$, $p < .001$, $f^2 = 27.47$), accounting for 96.49% of variance. Both regression models were sufficiently powered to detect the observed effects at conventional levels for power ($\beta = .80$) and significance ($\alpha = .05$). As predicted, both models explained high amounts of variance ($> 50\%$), suggesting high content validity. Nevertheless, we note that the eight features explained substantially more variance in challenge than in threat, potentially because threat judgments varied less across situations, such that restricted variance decreased the explained variance (see Figure 4.1). Another possibility is related to the conceptual content of the eight features. Because most of the features focused on positive aspects of the 20 situations (Table 4.2), they might have benefitted from greater conceptual overlap with challenge than with threat.

We further explored whether regression models that only included predictors with significant correlations in Figure 4.2 would describe the data satisfactorily. For threat, the reduced regression model thus included five predictors—intrinsic difficulty, skills and

resources, solution obviousness, anticipated loss, and coping ability. The reduced model significantly predicted threat ($F(5,14) = 9.65$, $p < .001$, $f^2 = 2.28$), accounting for 69.47% of variance (2% less than the full model). For challenge, the reduced model included four predictors—intrinsic difficulty, time and effort, solution obviousness, and coping ability. The reduced model significantly predicted challenge ($F(4,15) = 82.57$, $p < .001$, $f^2 = 17.17$), accounting for 94.50% of variance (also 2% less than the full model). Again, both regression models were sufficiently powered to detect the observed effects. We therefore explored whether the reduced regression models exhibited a similar model fit as the original regression models. Formal comparisons of the nested models using Analysis of Variance (ANOVA) returned non-significant differences between models for threat ($p = .307$) and for challenge ($p = .060$). These results suggest that the reduced models offered a similar model fit yet a more parsimonious solution. Subsets of five and four predictors, respectively, may therefore be sufficient for predicting and explaining threat and challenge across situations.

4.4.4 Hypothesis 2c: Feature profiles clustered situations meaningfully

We expected that the situations could be organized into meaningful clusters based on their similarity across threat, challenge, and the eight related features. To assess this hypothesis, we computed the Euclidean distance matrix on standardized data from our 20 feature profiles and performed hierarchical clustering ("hclust") using Ward-d agglomeration. We opted for hierarchical agglomerative clustering because it provides a flexible approach for small datasets without a priori knowledge of the number or shape of the clusters, and because it visualizes nested relationships via dendrograms enhancing the interpretability of the solution (C. X. Gao et al., 2023).

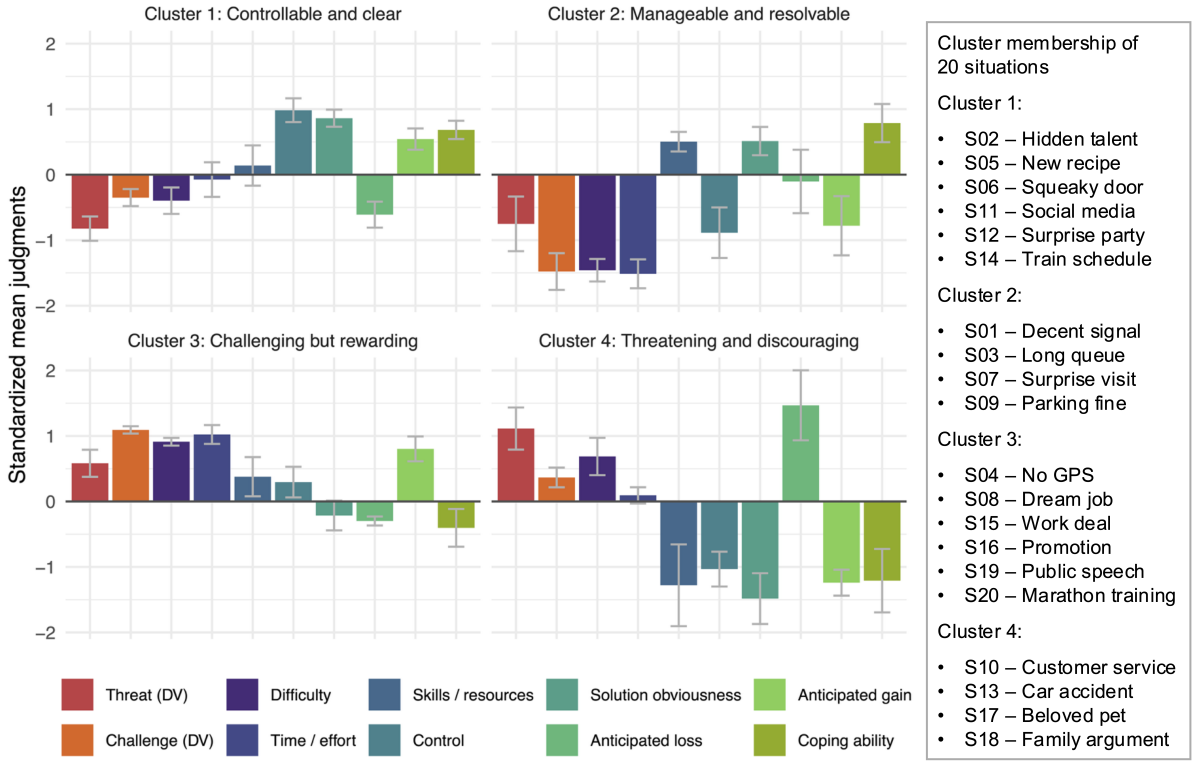
After considering the dendrogram and silhouette coefficients for solutions with two to five clusters, we opted for a four-cluster solution that presented with evenly sized clusters and conceptually meaningful feature profiles. The four-cluster solution also presented with the highest silhouette coefficient, .33 (Rousseeuw, 1987), suggesting somewhat overlapping clusters that likely reflect the systematically overlapping conditions used to generate the situations (see Table 4.1). Figure 4.3 illustrates the standardized feature profiles for the four clusters (see SM-9 for the dendrogram). Because the feature profiles are standardized, a score of 1 indicates that the level is 1 standard deviation (*SD*) above the average score across all situations (anchored at zero). Conversely, a score of –1 indicates that the score is 1 *SD* below the situation average.

The first cluster contains six situations that can be described as "controllable and clear," given that they received the highest judgments for control and solution obviousness across the four clusters. These situations further received above-average (above-zero) judgments for skills and resources, anticipated gain, and coping ability, suggesting that they lend clear

and rewarding action plans. "Controllable and clear" situations received below-average (below-zero) judgments for challenge and the lowest judgments for threat, suggesting that these situations are not perceived as particularly challenging or risky.

Figure 4.3

Standardized vector profiles of four clusters organizing 20 situations



Note. For each cluster, the standardized judgments for the assigned situations are depicted as bar plots (mean) with error bars (standard error) for each measure (challenge, threat, eight features). The zero-intercept marks the grand mean for each measure across all 20 situations. Scores > 0 suggest above-average levels whereas scores < 0 suggest below-average levels. $N = 81$

The second cluster includes four situations that can be described as "manageable and resolvable". Situations from this cluster presented with the highest average judgments for coping ability and for skills and resources but the lowest average judgments for challenge, intrinsic difficulty, and time and effort. When facing a situation from this cluster, individuals may easily resolve its requirements so that the situation becomes non-challenging (and non-threatening). Interestingly, "manageable and resolvable" situations scored below-average for control, perhaps indicating that their occurrence is out of the control of an individual.

The third cluster contained six "challenging but rewarding" situations that exhibited the highest average judgments for challenge, intrinsic difficulty, time and effort, and anticipated gain. "Challenging but rewarding" situations also showed above-average judgments for threat, suggesting that these situations pose some personal risk. The fourth cluster

contained four "threatening and discouraging" situations that presented with the highest average judgments for threat and anticipated loss, alongside the lowest average judgments of anticipated gain, coping ability, skills and resources, control, and solution obviousness. This cluster represents situations that individuals may try to avoid.

Interestingly, our four clusters are conceptually similar to psychophysiological states of challenge and threat in athletes (Jones et al., 2009; Meijen et al., 2020). "Threatening and discouraging" situations (Cluster 4) overlap with high threat states where athletes pursue goals under unfavorable conditions that are difficult to manage and cope with. Vice versa, "challenging but rewarding" situations (Cluster 3) overlap with high challenge states where athletes pursue goals under favorable conditions, likely returning gains and reward. "Controllable and clear" situations (Cluster 1) may resemble low threat states where athletes manage to control and cope with a stressful situation. Lastly, "manageable and resolvable" situations (Cluster 2) may resemble low challenge states where conditions are favorable, but athletes fail to control and benefit from the situation.

4.4.5 Hypothesis 3: LLM judgments approximated human judgments

We expected that the LLM would produce a similar pattern of results as the one the human participants produced. To test our hypothesis, we first computed the *absolute* differences (error) between each LLM-generated feature profile and each human-generated profile for each situation. For each of the 10 measures, we then computed the LLM's grand error across the 20 situations as well as the standard deviation to establish its error variance. We predicted small-to-moderate error for all measures that would be ≤ 2.5 on our 10-point scales, such that LLM versus human judgments both belonged to the same scale label presented every 2.5 points. Using the same procedure, we next computed the *signed* difference (bias) between each LLM-generated feature profile and each human feature profile. Similarly, we predicted small-to-moderate mean bias for the LLM that would be $\leq |2.5|$ for all measures. Positive bias would indicate that the LLM overestimated human judgments, whereas negative bias would indicate LLM underestimation. Lastly, we assessed relative differences between LLM feature profiles and human feature profiles by computing pairwise Spearman correlations for all measures.

Table 4.3 illustrates the LLM's judgments for each of the 10 measures (across situations), the LLM's error and bias of these judgments compared to the human judgments, and the LLM $\times$ human Spearman correlations for each measure. As predicted, LLM judgments exhibited small-to-moderate error and bias $\leq |2.5|$ for each measure when averaged across the 20 situations. Error and bias were largest for threat and anticipated loss, suggesting that the LLM was less accurate for negative measures. For all measures except time and effort, mean bias values were positive, suggesting that the LLM overestimated

human mean judgments across situations. Although the mean estimates for error and bias were below the hypothesized cut-off, their large standard deviations indicate that error and bias estimates were substantially higher for some of the 20 situations (and substantially lower for others). SM-10 presents the situation-specific results, showing that, for 17 of 20 feature profiles, at least one error and one bias estimate exceeded the hypothesized cut-off. These findings indicate that, although the LLM showed satisfactory judgment accuracy for aggregated measures, its prediction of individual feature profiles fluctuated considerably across situations and measures.

Table 4.3

Descriptive Statistics, Error, Bias, and Correlations for Situation-Level Measures

		Error	**Bias**	
Measures	***M (SD)***	***M (SD)***	***M (SD)***	ρ
Threat (DV)	4.49 (1.72)	2.02 (1.36)	1.99 (1.41)	.47*
Challenge (DV)	6.69 (0.64)	1.06 (1.09)	0.93 (1.21)	.78***
Intrinsic difficulty	6.36 (0.90)	1.60 (1.30)	1.35 (1.58)	.57**
Time and effort	5.77 (1.21)	0.90 (0.88)	–0.15 (1.27)	.64**
Skills and resources	6.45 (0.68)	0.49 (0.38)	0.30 (0.55)	.57**
Control	6.35 (1.21)	1.17 (0.76)	0.70 (1.22)	.56**
Solution obviousness	6.61 (1.05)	0.84 (0.49)	0.09 (0.99)	.31
Anticipated loss	5.13 (1.29)	2.32 (1.46)	2.24 (1.59)	.40*
Anticipated gain	6.09 (2.01)	0.80 (0.92)	0.63 (1.05)	.92***
Coping ability	6.93 (0.69)	1.02 (0.91)	0.45 (1.31)	.25

Note. LLM-generated judgments for threat and challenge (dependent variables) followed by the eight features. Error represents the absolute difference between LLM judgments and human judgments. Bias represents the signed difference between LLM judgments and human judgments. Positive bias indicates that the LLM overestimated human judgments; negative bias indicates underestimation by the LLM. Pairwise Spearman correlations depict the relation between LLM judgments and human judgments. Significant correlations for one-sided confirmatory predictions are marked with * $p < .05$; ** $p < .01$; *** $p < .001$. M = mean; SD = standard deviation. $N_{LLM} = 50$; $N_{partic} = 81$

The results from the pairwise Spearman correlations show that most coefficients support our prediction of large significant correlations > .30, except for solution obviousness (non-significant) and coping ability (below cut-off and non-significant). The largest pairwise correlations were observed for anticipated gain ($\rho = .92$) and challenge ($\rho = .78$), suggesting that the LLM exhibited the most similar judgment patterns to our participants when judging positive measures. Overall, our findings for error, bias, and pairwise Spearman correlations suggest that the LLM was able to generate judgments, that on

average, approximated human judgments. Nevertheless, large variability in error and bias estimates indicate that the accuracy of LLM judgments varies substantially across situations and measures.

4.4.6 Discovery: Predicting structural relations with LLMs

In two discovery analyses, we explored whether the LLM feature profiles would reflect structural relationships between measures that were present in the human feature profiles. For our first discovery analysis, we computed two congruent Spearman correlation matrices: The first matrix depicted the pairwise correlations between all measures using the LLM feature profiles. The second matrix depicted the pairwise correlations between all measures using the human feature profiles (see also Figure 4.2). We then computed the difference matrix between the LLM and human correlations.

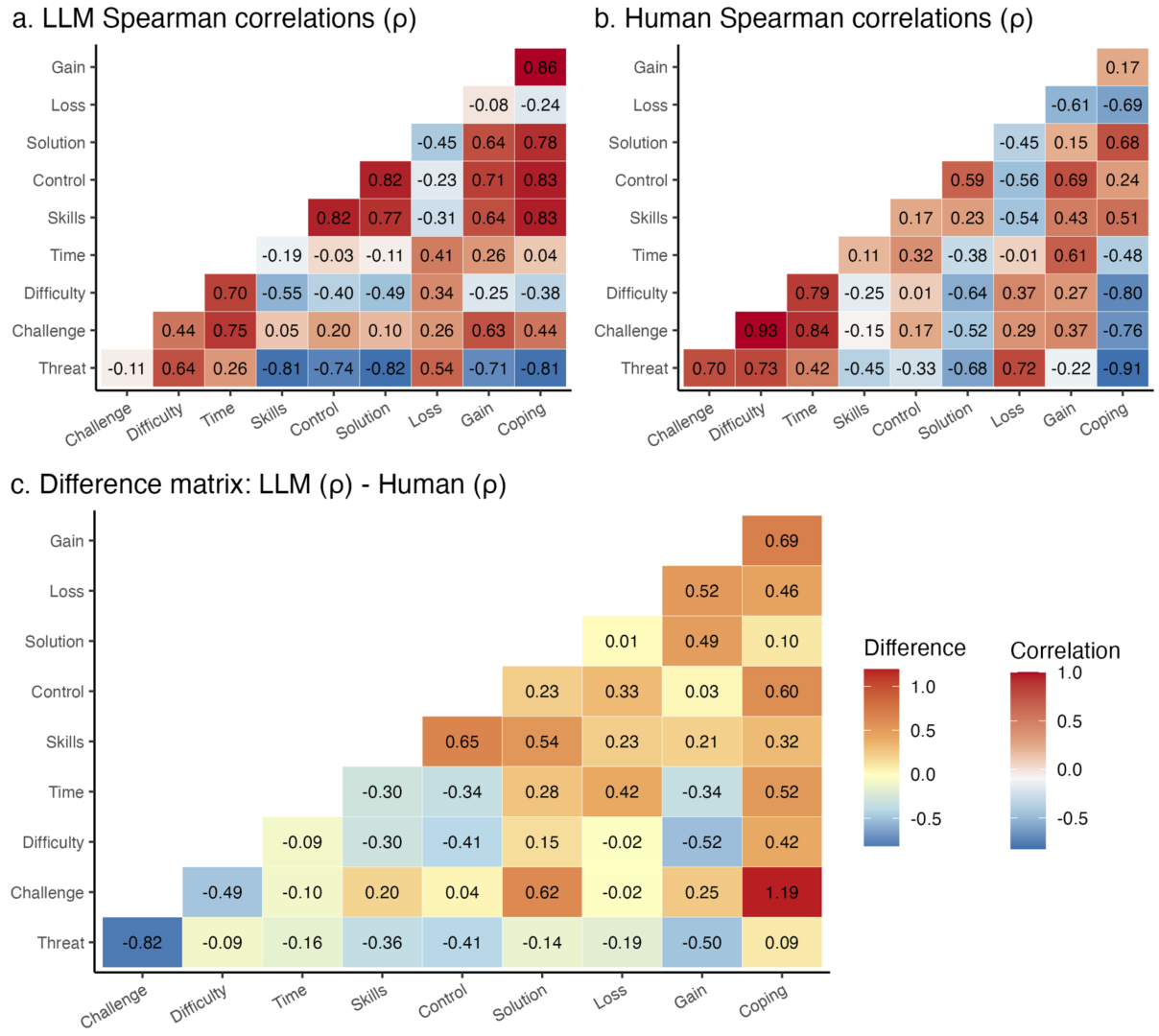
Figure 4.4 illustrates the LLM pairwise correlations (panel A), the human pairwise correlations (panel B), and the difference between both correlation matrices (panel C). In panel C, yellow cells indicate a (close-to) zero difference between correlation coefficients, suggesting that the LLM correlation approximated the human correlation. Orange and red cells indicate a positive difference, suggesting that the LLM correlation overestimated the human correlation. Conversely, green and blue cells indicate a negative difference, suggesting the LLM correlation underestimated the human correlation.

As illustrated by the overall orangeness/redness of Figure 4.4c, the LLM correlations more commonly overestimated than underestimated correlations between measures in the human data. Whereas the LLM correlations tended to overestimate human correlations for coping ability, solution obviousness, and skills and resources, they tended to underestimate human correlations for threat, intrinsic difficulty, and time and effort. Although LLM judgments closely reflected 10 out of 45 pairwise correlations (indicated by yellow tiles), the absolute mean difference between all correlations was 0.45, suggesting substantial misjudgments in correlational strength and directionality. These findings highlight that while LLM-generated judgments may be able to mimic human judgments in isolation, they may be less useful for predicting inter-variable structural relationships.

In a second discovery analysis, we tested whether the LLM-generated feature judgments, when combined, would explain high amounts of variance in threat and challenge across situations. To do so, we computed a pair of group-level linear regressions for threat and an analogous pair for challenge. In the first regression of each pair, we predicted the LLM judgments for threat or challenge with the LLM judgments for the eight features. In the second regression of each pair, we predicted the human judgments for threat or challenge with the LLM judgments for the eight features. All discovery models were sufficiently powered to detect effects ≥ 0.36 (at $\beta = .80$ and $\alpha = .05$).

Figure 4.4

LLM versus human Spearman correlations and their difference matrix



Note. Panels (a) and (b) present pairwise Spearman correlations between measures from LLM-generated feature profiles and human feature profiles. As a cell becomes increasingly red, the coefficient increasingly approached 1. As a cell becomes increasingly blue, the coefficient increasingly approached –1. As a cell becomes increasingly white, the coefficient increasingly approached 0. Panel (c) presents the difference matrix between (a) and (b). As a cell becomes increasingly orange/red, the LLM correlation increasingly overestimated the human correlation. As a cell becomes increasingly green/blue, the LLM correlation increasingly underestimated the human correlation. As a cell become increasingly yellow, the LLM correlation increasingly matched the human correlation. ρ = Spearman coefficient. $N_{LLM} = 50$; $N_{partic} = 81$

Our discovery models that only included LLM judgments significantly predicted threat ($F(8,11) = 19.37$, $p < .001$, $f^2 = 7.73$) and challenge ($F(8,11) = 5.21$, $p < .01$, $f^2 = 1.77$), accounting for 88.55% and 63.94% of variance, respectively. Predicting and explaining

the LLM's own threat and challenge judgments suggests that the LLM-generated feature profiles are internally coherent. Notably, the LLM-only regression explained 30% less variance in challenge relative to the human-only regression in Hypothesis 2c (63.93% vs 96.49%). Interestingly, however, the LLM-only regression explained about 15% more variance in threat relative to the analogous human-only regression in Hypothesis 2c (88.55% vs 71.62%), perhaps indicating that the simulated data reflects theorized relations with threat more closely than data from human participants. Our discovery models that predicted human threat and challenge with LLM feature measures did not predict threat significantly ($F(8,11) = 1.28$, $p = .335$, $f^2 = 0.12$) but predicted challenge significantly ($F(8,11) = 4.49$, $p < .05$, $f^2 = 1.47$), accounting for 10.45% and 59.52% of variance, respectively. Because the observed effect size from the threat regression was smaller than the minimum observable effect of 0.36, our statistical model was not sufficiently powered to detect the observed effect. These results suggest that LLM-generated feature judgments can explain substantial variance in human judgments for challenge but results are inconclusive for threat. Considering the findings reported earlier for Hypothesis 3, this could be because the LLM was better at predicting positive measures compared to negative measures.

4.5 Discussion

This study aimed to develop and evaluate feature profiles for a set of real-life situations that comprehensively represent experiences of threat, challenge, and their associated features in UK adults. We used an open-source LLM to generate a large pool of candidate situations, capturing a broad spectrum of difficult experiences that UK adults typically encounter. To norm the 20 final situations, 81 UK adults judged each situation on dimensions of threat, challenge, and eight theory-derived features. Aggregating these judgments yielded a 10-dimensional feature profile for each situation. We also prompted the open-source LLM to judge the 20 situations on the same ten dimensions, thereby simulating the judgments of our participants.

4.5.1 Establishing reliable feature profiles of difficult situations

As illustrated in Figure 4.1, feature profiles exhibited distinct combinations of high versus low judgments across the 10 measures, indicating that the 20 situations spanned the space of difficult experiences comprehensively. Differences between situations were most pronounced for anticipated loss and anticipated gain, reflecting the loss–gain combinations that guided situation generation (Table 4.1). In contrast, variance was more constrained for other features, such as available skills and resources, solution obviousness, and threat.

Contrary to Hypothesis 1a, neither threat nor challenge judgments spanned the hypothesized scale range (2.5–7.5 on a 10-point scale). Whereas challenge levels were moderate on average, threat levels were low across situations. One explanation may be that the LLM prompts were not calibrated to elicit highly threatening situations. Capturing such experiences may require prompts that explicitly request rare or atypical events (e.g., being mugged, facing eviction), or the use of established stress inventories that include highly threatening life events (e.g., death of a spouse; Holmes & Rahe, 1967). Another possibility is that highly threatening situations are relatively uncommon in the daily lives of UK adults. Individuals may actively avoid such situations, and repeated exposure to unavoidable stressors may reduce perceived threat through the acquisition of coping resources.

Despite these distributional constraints, the feature profiles of the 20 situations were highly reliable. In line with Hypothesis 1b, mean judgments for threat, challenge, and all eight theory-derived features demonstrated substantial reliability despite our modest sample size (Table 4.2). These findings indicate that future norming studies may achieve comparable reliability for the feature profiles of situations with relatively limited resources.

4.5.2 Insights into the constructs of threat and challenge

Building on this foundation, a second aim of this project was to examine how threat and challenge relate to the eight theory-derived features: intrinsic difficulty, time and effort, skills and resources, control, solution obviousness, anticipated loss, anticipated gain, and coping ability. We first assessed construct validity by computing pairwise Spearman correlations for threat and challenge with each feature across the 20 situations. Contrary to Hypothesis 2a, only about half of the features exhibited significant correlations $> |.30|$, although many were directionally consistent with the original predictions.

Perhaps most interestingly, correlational patterns for threat and challenge were highly similar (Figure 4.2), when partial inverses between them were expected. These largely overlapping patterns suggest that both constructs share core features of difficult situations, particularly increasing difficulty, less obvious solutions, and decreasing ability to cope, indicating that the properties intrinsic to the situation and the individual's experience of the situation are central to experiences of both threat and challenge. To us, this is a surprising and informative result. It is striking how similar threat and challenge are to each other, as reflected in the patterns of situational features that predict them. Rather than being inverses, threat and challenge clearly align in important ways with the feature profiles of difficult situations.

Perhaps threat and challenge differ most in their valence. Whereas threat is associated with a negative affective response to a difficult situation, challenge is associated with a positive affective response. Because we didn't anticipate that this might be the major dif-

ference between threat and challenge, with other situational features exhibiting similarity between them, we didn't assess positive and negative affect in this study. Clearly, this is an important topic for future work.

Perhaps there are hints in our current dataset that are consistent with the above speculation. Although both threat and challenge showed positive associations with anticipated loss (inconsistent), threat tended toward a negative association with anticipated gain, while challenge tended toward a positive one (consistent). Notably, most of these correlations were not statistically significant, perhaps because loss and gain exhibited complex patterns across a relatively small number of situations. If our speculation here is correct, stronger relations may emerge when assessing negative and positive valence directly, rather than through loss and gain. It might also be interesting to explore other features associated with valence that affective differences as well, such as rumination, worry, and pessimism on the negative side, along with savouring, flow, and optimism on the positive side.

Another hint in the data that valence is important comes from our assessment of content validity. When we assessed how comprehensively the eight features explain variance in threat and challenge, we found that content validity was high. As predicted for Hypothesis 2b, the features accounted for a large proportion of variance in both threat (72%) and challenge (96%). The somewhat lower explained variance for threat could have reflected its restricted range (Figure 4.1) and/or the emphasis of most features in the feature profiles capturing positive aspects of situations. This latter explanation is consistent with valence being the important difference between threat and challenge: content validity was higher for challenge than for threat because there were more positive predictive features than there were negative predictive features. Because challenge received better coverage from the positive features assessed than threat received from the negative features assessed, content validity was higher for challenge. Of interest in future work is whether balancing the number of positive and negative features removes this difference in content validity.

Finally, we examined whether the 10-dimensional feature profiles could capture patterns of similarities and differences in the 20 situations. As predicted in Hypothesis 2c, clustering analyses revealed four evenly sized and conceptually coherent groups: "controllable and clear," "manageable and resolvable," "challenging but rewarding," and "threatening and discouraging." Our clustering approach thereby contrasts earlier stress inventories that typically treat situations as isolated events and simply rank them by severity. By decomposing situations into feature profiles and grouping them into theoretically robust clusters, our approach provides a more nuanced framework for understanding how threat and challenge manifest across difficult everyday experiences.

4.5.3 Applying large language models (LLMs) to psychological research

The third aim of this project was to evaluate whether an open-source LLM could generate feature profiles that approximate those produced by human participants. As predicted in Hypothesis 3, the LLM produced judgments that broadly approximated human judgments when aggregated across all 20 situations (see Table 4.3). Accuracy, however, varied substantially across measures and situations, highlighting the need for systematic validation against participant data.

We further explored whether the LLM could capture the structural relationships observed in the human feature profiles. Spearman correlation matrices from LLM-derived profiles exhibited substantial divergences to correlations from human-derived profiles both in strength and direction of correlations. For instance, the LLM suggested that coping ability was negatively associated with threat but positively associated with challenge—a pattern consistent with some theoretical models but not consistent with our participant data, where both threat and challenge showed strong negative correlations with coping ability. In group-level linear regressions, LLM-derived features accounted for substantial variance in human judgments for challenge (60%) but not for threat (10%), suggesting that the LLM was more accurate when predicting positive dimensions than negative ones.

These findings highlight the need for caution in applying LLMs as substitutes for human participants. Although our results were robust across multiple temperature settings, recent work suggests that LLM outputs are sensitive to researcher decisions (e.g. model choice, prompt content; Cummins, 2025). Moreover, the accuracy of LLM judgments depends on the representativeness of their training data that often underrepresents non-WEIRD populations (Grossmann et al., 2023). As a result, LLMs may mischaracterize the experiences of groups not well captured in their training corpora. This limitation has led some scholars to advocate against treating LLMs as study participants (e.g., Schröder et al., 2025). Our findings are consistent with this perspective: Whereas the LLM functioned effectively as a generative assistant for producing candidate situations, it proved less reliable as a surrogate for human judgment.

4.5.4 Identifying suitable contexts for stress interventions

The findings from this study can inform stress interventions. Because difficult situations are a necessary prerequisite for stress responses (Lazarus & Folkman, 1984; Selye, 1936), effective stress interventions must be context sensitive: interventions should not only target the individual but also account for the situational conditions that elicit the stress that the individual experiences. A contextualized intervention aimed at managing the stress in an individual's life could identify the stressful situations they encounter and

then characterize which features of the situation—and which transactions between the individual and the situation—contribute most to their stress response. Depending on whether situational or transactional features are most influential, interventions could be designed to either restructure the environment or to empower individuals in ways that change their response to a specific difficult situation. Importantly, while many interventions focus on reducing stress, an equally promising approach is to optimize stress responses by shifting experiences from distress to eustress (Crum et al., 2020; Jamieson et al., 2018).

Two broad intervention strategies emerge from this perspective. The first is stress reduction that aims to minimize all types of difficult situations (i.e., threats and challenges). This can involve restructuring environments to reduce situational demands (e.g., lowering intrinsic difficulty, reducing time and effort required, making solutions more obvious), or train an individual to cope effectively with specific situations. The second broad intervention strategy is stress optimization that aims to transform stressful experiences into opportunities for growth. This approach focuses on decreasing threat through enhancing challenge, for example by restructuring environments to increase situational resources (e.g., greater perceived control, more skills available). At the transactional level, interventions can help individuals to increasingly appraise potential gains and decreasingly appraise potential losses, thereby motivating individuals to reframe difficult situations as manageable challenges rather than overwhelming threats. Thus, understanding the feature profiles of difficult situations can help identify suitable contexts for different types of stress interventions.

4.5.5 Limitations and further directions

A key limitation of this study is the relatively small set of 20 situations that we normed. Because these situations were developed with the assistance of an open-source LLM, their content depends on both the model's training corpora and the quality of our prompts (Demszky et al., 2023). Conversely, the content of the 20 situations may have influenced their feature profiles and subsequent analyses. Threat judgments, for instance, exhibited low levels and restricted variance, potentially limiting the differentiation between threats and challenges and constraining tests of how well the eight features explained variance in threat. The limited number of situations also reduced power to detect complex, nonlinear associations between features. Future research should therefore expand the set of normed situations to include less frequent but relevant stressors, enabling a more comprehensive database to explore complex relationships between features.

Another limitation concerns our non-probabilistic sample of 81 UK adults, whose aggregated judgments formed the 10-dimensional feature profiles. Although our sample approximated UK population levels for some demographics (e.g., annual income), participants were recruited without known selection probabilities, limiting the generalizability of

results to broader populations (Heeringa et al., 2017). Because feature profiles relied exclusively on self-report judgments, they may be subject to measurement error (Corneille & Gawronski, 2024). Similarly, LLM outputs may not generalize across models, hyperparameters, or target populations. Future research should therefore test human feature profiles using probabilistic and demographically representative samples, as well as evaluating the validity of LLM-generated feature profile before drawing psychological inferences.

Finally, this study has clear design limitations. Although our eight theory-derived features explained substantial variance in threat and challenge, other features (e.g., rumination) may also capture key aspects of difficult experiences. Adding more negative features could improve the prediction of threat, and including more valence-related features might better help understand the difference between threat and challenge, which otherwise both appear heavily related to the difficulties of situations in the same way. Finally, as a norming study, our correlational design does not allow causal inference. Future research could build on these findings by experimentally manipulating situational and transactional features to directly test their causal influence on threat and challenge responses, thereby linking descriptive mapping with mechanistic understanding of stress processes.

4.6 Conclusion

Using an open-source LLM, we developed feature profiles for 20 real-life difficult situations that UK adults typically encounter. Using a UK-adult sample, we established each situation's features for threat, challenge, and eight theory-derived predictors. Although the resulting 10-dimensional feature profiles exhibited restricted variance on some measures, they were highly reliable and thus allow for investigating the features that characterize difficult situations and that distinguish threat and challenge. Spearman correlations and linear regressions revealed, surprisingly, that highly similar patterns of features predicted and explained threat and challenge across situations, with the possibility of valence being the feature that primarily distinguishes threat from challenge (an issue that awaits further research). The feature profiles also revealed meaningful clusters of situations, highlighting the potential of feature profiles to identify and design suitable real-life contexts for stress interventions. When trying to reproduce human-generated feature profiles with an LLM, we found that LLM judgments were able to approximate human judgments overall but failed to capture detailed structural relationships observed in human data. Thus, our findings align with emerging research that, although useful as a researcher assistant, LLMs are less reliable as surrogates for human judgments.

Chapter 5

Coping, fulfilment, and successful outcomes: Assessing sources of eustress across real-life challenging situations

This chapter is an exact copy of the following publication:

Kloidt, J. & Barsalou, L. W. (2025). *Coping, fulfilment, and successful outcomes: Assessing sources of eustress across real-life challenging situations.* PsyArxiv. https://doi.org/10.31234/osf.io/m8txb_v1

This study was preregistered at: https://osf.io/ydc25/

We have uploaded supplemental materials to the Open Science Framework including raw data, analysis files, and supplemental results files. They can all be accessed here: https://osf.io/62mn5/

5.1 Abstract

Measuring the processes that influence eustress—the positive experience of a challenging situation—is essential for understanding and fostering it effectively in applied contexts. Using the Situated Assessment Method, we conducted a preregistered study where 251 UK adults judged their eustress across 20 previously evaluated real-life challenging situations (e.g., "Give a public speech in front of a large audience"), along with nine influential processes (e.g., coping, fulfilment) taken from the Comprehensive Hierarchical construct of Eustress (CHE). Participants also completed trait-level measures for eustress, distress, and stress mindsets. We observed reliable individual differences, substantial situation effects, and large individual-situation interactions in eustress judgments. The nine influential processes correlated strongly with situated eustress, explaining a median variance of 83% in individual-level regressions. Individual measures of eustress, averaged across situations, correlated with trait eustress and stress-is-enhancing mindsets but were unrelated to trait distress. Exploratory factor analyses on situational and trait-level processes revealed a dominant general factor that strongly correlated with individuals' eustress judgments. Our findings align with existing theories of stress, contrast different types of eustress measurement, and provide rich descriptive profiles for personalized and context-sensitive interventions to foster eustress when desirable.

5.2 Introduction

Eustress is a positive stress response that emerges from transactions between the individual and their immediate environment (cf. Lazarus & Folkman, 1984; Lazarus & Folkman, 1987). Individuals express eustress in various ways that can be cognitive (e.g., insightful appraisals, meaning), affective (e.g., fulfilment, excitement), and behavioral (e.g., coping, engagement), together impacting on the individual's wellbeing, productivity, learning, and personal growth (Kloidt & Barsalou, 2024; Lazarus & Folkman, 1984; Simmons & Nelson, 2007). Eustress emerges from situations that are appraised as challenging, with most research to-date focusing on professional settings, including corporations (Cavanaugh et al., 2000), social services (Rodríguez et al., 2013), and universities (Gibbons et al., 2009; O'Sullivan, 2011). By focusing on positive experiences in challenging situations (e.g., being excited about giving a public speech), eustress remains conceptually distinct from wellbeing, which typically occurs in non-challenging settings (e.g., being excited about relaxing at home). Nevertheless, the two constructs appear closely related (Kloidt & Barsalou, 2024).

Although eustress has been conceptualized as the response to a transactional process (cf. Lazarus & Folkman, 1987), relatively little research has addressed how individuals experience eustress *across* various areas of life and what underlying processes are related to it in these situations. Understanding what processes influence positive experiences of stress in real-world settings is crucial to inform contextualized interventions for pivoting from distress to eustress. The primary aim of this study was therefore to measure how UK adults experience eustress and its underlying processes across real-life challenging situations where it occurs. We employed the Situated Assessment Method (SAM^2; Dutriaux et al., 2023) to quantify self-reported eustress across individuals and challenging situations, and to identify key processes, such as coping, fulfilment, and successful outcomes, that influence it.

5.2.1 The Situated Assessment Method (SAM^2)

To understand a behavior in real-world settings, SAM^2 proposes that researchers should measure the behavior in situations where it may occur, instead of ignoring situations or abstracting over them. The few existing eustress instruments typically adopt an *unsituated* approach, using decontextualized items, such as "In general, how often do you feel motivated by your stress?" (O'Sullivan, 2011). Certainly, these instruments add to our understanding of eustress as a theoretical construct and its general distribution across populations. Answering these items, however, can be difficult because individuals must abstract over situations and establish general impressions of how much they agree with general statements about eustress. Individuals may instead rely on intuitive theories and/or

the availability heuristic (sampling a few salient situations) to arrive at their judgment, potentially leading to unrepresentative or inaccurate responses (Ajzen, 1977; Gelman & Legare, 2011; Tversky & Kahneman, 1973).

For these reasons, SAM^2 assesses a target behavior in specific situations where it is likely to occur. A large and well-established body of literature demonstrates that individual behaviors vary substantially across situations (Bandura, 1978; Cervone et al., 2001; Fleeson & Jayawickreme, 2021; Mischel & Shoda, 1995). For example, an individual may regularly experience eustress when performing their favorite piece of music or when presenting projects at work but rarely experience eustress when resolving family conflicts.

SAM^2 further proposes that it is useful to assess processes in these situations that are likely to influence the target behavior. Whereas feeling engaged and fulfilled may be the main source of eustress when performing music, productivity and successful goal achievement may drive eustress during a project presentation. Additionally, different individuals may respond differently to the same situations, resulting in individual-situation interactions. Whereas one individual may experience eustress mostly in situations where a goal is pursued actively (e.g., presenting a work project), another individual may experience eustress mostly when engaging with the moment (e.g., performing a favorite piece of music). For these reasons, SAM^2 not only assesses a target behavior across situations, but also processes likely to influence it. Typically, empirical literatures related to the target behavior inform the selection of potentially important processes to assess.

In summary, SAM^2 collects measurements in two dimensions of situatedness: (1) relevant situations where the target behavior may occur and (2) situational processes likely to influence the behavior in these situations. SAM^2 assessments have successfully established influences on everyday habits (Dutriaux et al., 2023), water drinking (Rodger et al., 2024), trichotillomania (Taylor Browne Lūka et al., 2024), and climate anxiety (Hill-Harding et al., 2024), typically explaining about 75% of the variance in an individual's target behavior. Thus, to implement the SAM^2 framework for the target behavior of eustress, we first identified a set of real-world challenging situations and then identified processes in the literature that potentially influence eustress in them.

Establishing challenging situations where eustress occurs

The SAM^2 approach assesses target behaviors in individuals using a standardized set of situations. Strengths of this approach over other situated methods include that SAM^2 can be performed efficiently in a single session and that individuals evaluate the same set of situations that offer a common standard of measurement (for a detailed discussion, see Dutriaux et al., 2023).

For this study, we extracted a comprehensive yet diverse set of 20 situations that represent different intensities and types of challenge in a UK context (Table 5.1). The 20

situations were previously evaluated by 81 UK adults in a related study (Kloidt et al., 2025), suggesting that the average challenge judgments ranged from low to high across situations, making this an appropriately diverse sample for the study here. The 20 situations further differed in their associations between challenge and its underlying processes (e.g., intrinsic difficulty, anticipated loss, anticipated gain), suggesting that different situations captured different types of challenges. Because the 20 situations represented different intensities and types of challenge, they should capture diverse manifestations of eustress with unrestricted variance. As Dutriaux et al. (2023) describe, presenting these situations to participants is likely to activate specific situational memories from their daily life that they then evaluate when responding to survey items.

Table 5.1

The 20 situations extracted from Kloidt et al. (2025)

Identifier	**Situation**
S01 – Decent signal	Try to find a decent Wi-Fi signal at a coffee shop.
S02 – Hidden talent	Discover a hidden talent for photography and start sharing your work online.
S03 – Long queue	Get stuck in a long queue at the post office.
S04 – No GPS	Try to navigate a new city without a map or GPS.
S05 – New recipe	Try to cook a new recipe with many steps for the first time.
S06 – Squeaky door	Try to fix a stubborn squeaky door in your flat.
S07 – Surprise visit	Handle a surprise visit from an old friend gracefully.
S08 – Dream job	Start the process of finding and getting your dream job.
S09 – Parking fine	Deal with a parking fine for overstaying in a parking spot.
S10 – Customer service	Deal with a difficult customer service representative.
S11 – Social media	Try to break free from your social media habits to focus on your mental health.
S12 – Surprise party	Plan a surprise party for a loved one.
S13 – Car accident	Handle the consequences of a minor car accident.
S14 – Train schedule	Navigate a complex train schedule to get to a meeting on time.
S15 – Work deal	Try to close a big deal at work and receive a significant bonus.
S16 – Promotion	Take on new responsibilities after receiving a promotion.
S17 – Beloved pet	Say goodbye to a beloved pet about to be put to sleep.
S18 – Family argument	Get into a heated argument with a family member over a sensitive topic.
S19 – Public speech	Give a public speech in front of a large audience.
S20 – Marathon training	Develop and successfully execute a training plan to run your first marathon.

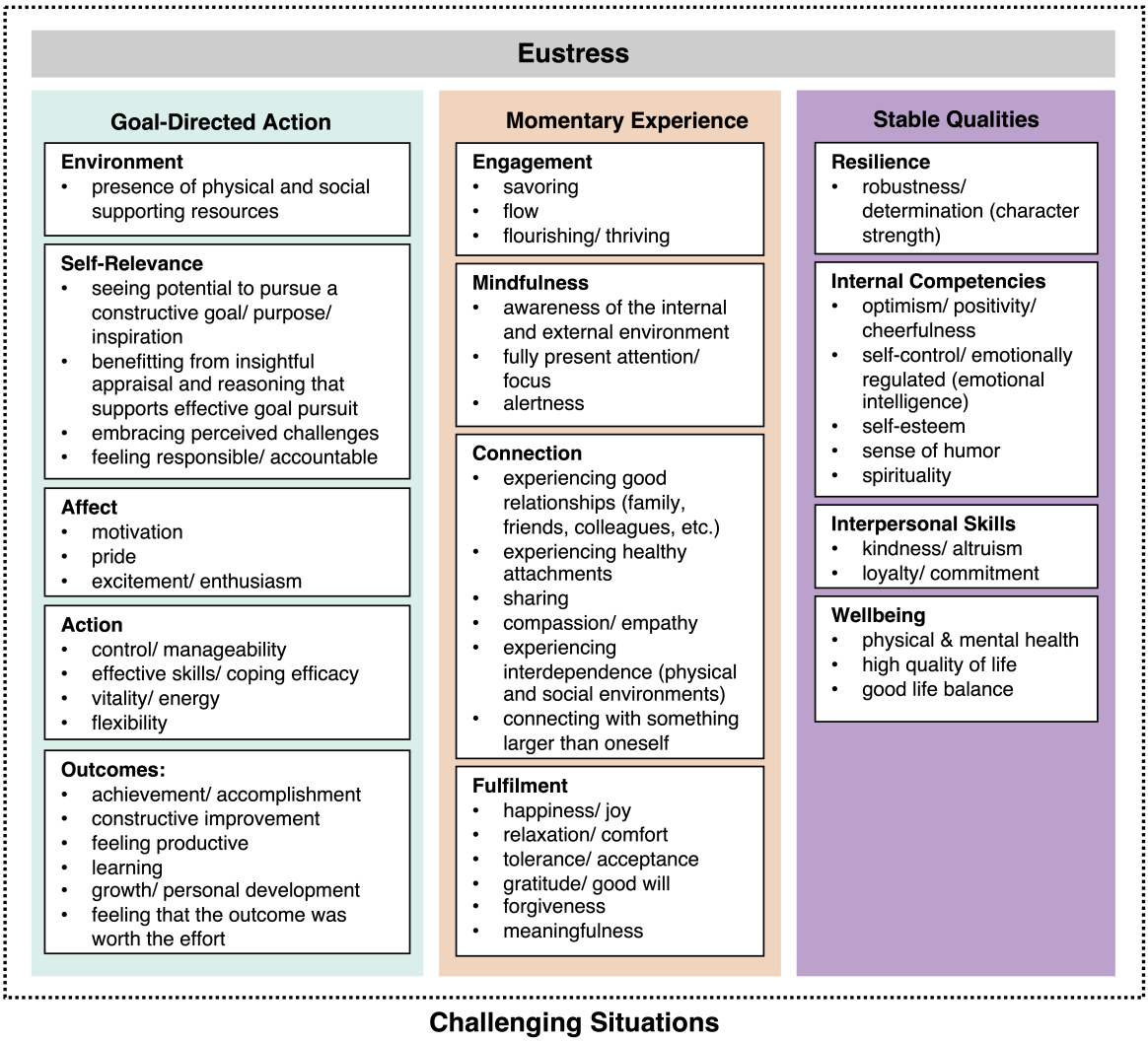
Establishing influential processes of eustress in these situations

To establish a comprehensive list of influential processes on eustress in these situations, we focused on a recent theoretical model–the Comprehensive Hierarchical construct of

Eustress (CHE; (Kloidt & Barsalou, 2024))–because it integrates diverse eustress research from 80 articles and has been evaluated in a well-powered UK adult sample (Kloidt & Barsalou, 2026). Figure 5.1 presents the CHE model (reproduced from Kloidt & Barsalou, 2024).

Figure 5.1

Comprehensive Hierarchical construct of Eustress (CHE)



Note. CHE depicts three hierarchical levels of organization. The highest level are three eustress sources, depicted as colored columns (bolded headers). The sources contain 13 mid-level facets, illustrated as white boxes within each column (bolded box headers). The lowest level are 47 features organized into facet boxes (bullet points)

According to CHE (and the diverse literatures on which it is based), individuals generate eustress in challenging situations from three main sources: successful goal-directed action, fulfilling momentary experience, and positive stable qualities. As shown in Figure 5.1, the three high-level sources of eustress (colored columns) are organized into 13 distinct

mid-level facets (white boxes) that cluster 47 conceptually related features (bullet points) at the lowest hierarchical level.

To establish influential processes for evaluation in our SAM^2 instrument, we extracted CHE's nine mid-level facets from the two sources of eustress in CHE most likely to influence eustress at the situational level: goal-directed action and momentary experience. We chose mid-level facets as they offered a balance between the high-level sources that would be too abstract and the low-level features that would be too detailed and that would likely introduce redundancy to our measurement. We extracted the facet labels from Figure 5.1 and added details from their features where necessary to construct explicit measurement variables (e.g., affect → positive affect).

We did not operationalize CHE's third source of eustress—stable qualities—within our SAM^2 instrument because, as the name suggests, it constitutes traits that remain relatively stable across all challenging situations. As a result, they cannot be measured in a SAM^2 instrument, which requires that test items vary across situations. Instead, we measured trait eustress separately from SAM^2 at the individual level, using a subscale of the Comprehensive Hierarchical Eustress Review that assesses these traits (CHER-Qual; Kloidt & Barsalou, 2026). Later analyses will examine prediction at both the situational and individual levels. At the situational level, the nine facets for goal-directed action and momentary experience will be assessed. At the individual level, stable qualities will be assessed, along with other trait measures, including trait-level measurements of goal-directed action and momentary experience, constructed by averaging their facets across situations.

5.2.2 Overview and hypotheses

The current work aimed to investigate how individuals experience eustress and its underlying processes across real-life challenging situations where eustress is likely to occur. To do so, we developed a SAM^2 instrument for assessing eustress in a situated manner. We asked a well-powered sample of UK adults to evaluate their eustress experiences across the diverse set of 20 everyday challenging situations presented in Table 5.1. We also asked our participants to evaluate the same situations on the nine eustress facets (processes) that we sampled from the CHE model. In addition to the situated eustress instrument, participants completed three trait-level measures: the Comprehensive Hierarchical Eustress Review subscale for Stable Qualities (CHER-Qual; Kloidt & Barsalou, 2026), the Perceived Stress Scale (PSS-10; Cohen et al., 1983), and the Stress Mindset Measure (SMM; Crum et al., 2013).

This study was preregistered on the Open Science Framework (https://osf.io/ydc25). To evaluate the SAM^2 instrument for assessing eustress, we addressed the following hypotheses:

Hypothesis 1: Large reliable individual differences in eustress

We expected that the mean eustress judgments for each individual across situations would range across at least half of our 10-point rating scale from 2.5 to 7.5, meaning that participants exhibit large trait-level differences in eustress. We further expected that individual-level eustress judgments would exhibit satisfactory reliability (Cronbach's alpha $> .80$).

Hypothesis 2a: Substantial situation effects

We expected that a given participant would report high levels of eustress in some situations but little to no eustress in others. Based on previous studies, we expected that at least 33% of participants would range from 1 to 9 in their eustress judgments across situations on our 10-point rating scale, at least 67% of participants would range from 2 to 8, and at least 90% of participants would range from 3 to 7.

Hypothesis 2b: Substantial individual-situation interactions

We expected that participants would differ considerably in how they experience eustress in the same situations, so that the intraclass correlation for agreement between participants would be low ($ICC2 < .40$).

Hypothesis 3a: CHE's facets for goal-directed action and momentary experience constitute situational processes related to eustress

We expected that most (if not all) of CHE's facets would be strongly related to eustress judgments across situations, indicating high construct validity of the SAM^2 instrument. Specifically, we expected largely-sized positive correlations between eustress and each facet within a given individual ($> .30$; cf. Funder & Ozer, 2019; Gignac & Szodorai, 2016). As found previously in the literature, these facets should emerge as situational processes associated with eustress.

Hypothesis 3b: CHE's facets for goal-directed action and momentary experience explain individuals' eustress in situations

We predicted that CHE's facets combined would comprehensively explain high amounts of variance in individual-level regressions ($> 50\%$). We thus expected that the influential processes explain eustress comprehensively, indicating high content validity of the SAM^2 eustress instrument.

Hypothesis 4: Low correlations between situated eustress and unsituated measures

We expected that the SAM^2 measure for eustress at the individual level (an individual's mean eustress across situations) would exhibit a small-to-medium, positive correlation ($<$ .30) with the CHER-Qual sub-scale (i.e., trait eustress; Kloidt & Barsalou, 2026) and the SMM (i.e., stress-is-enhancing mindset; Crum et al., 2013). We also expected a small-to-medium, negative correlation ($< |.30|$) between the SAM^2 measure for eustress and the PSS-10 (i.e., trait distress; Cohen et al., 1983).

Discovery

In a discovery analysis, we investigated whether facets from the same CHE source of eustress (goal-directed action, momentary experience, and stable qualities) would load on a common factor using confirmatory factor analysis. We also conducted exploratory factor analyses to compare the best fitting exploratory model with our confirmatory models. Analogous to Hypothesis 4, we investigated whether factor scores from our discovery analysis would be correlated with the SAM^2 measure for eustress.

5.3 Methods

5.3.1 Participants

Ethical approval was granted by the College of Medical Veterinary and Life Sciences at the University of Glasgow (application 200240232). We recruited a sex-balanced sample via the Prolific online platform that met the following inclusion criteria: UK residents, aged 18 to 80 years old, self-reported English fluency, and completion of at least 20 Prolific studies with 100% approval rate. As correlations stabilize at approximately 250 datapoints (Schönbrodt & Perugini, 2013), we recruited a slightly larger sample and inspected our data for mechanical or random responses. We excluded four participants for providing such responses, resulting in a final sample of 251 UK adults. Table 5.2 presents the sample's demographic features, which approximated UK population demographics for annual income but exhibited slightly higher educational qualifications than the population average (Office for National Statistics, 2021, 2025).

Table 5.2

Participant demographics

Demographic	***M (SD)***	**Range**
Age	44.00 (14.43)	19 – 80
	Count	**Proportion**
Gender identity		
Man	125	.50
Woman	125	.50
Genderqueer / Non-binary	1	.00
Annual income		
Below £10,000	29	.12
£10,001 – £20,000	42	.17
£20,001 – £30,000	74	.29
£30,001 – £40,000	42	.18
£40,001 – £50,000	34	.14
Above £50,001	30	.12
Years spent in formal education		
10 years or less (Level 1 or no qualification)	10	.04
11 – 12 years (Level 2)	35	.14
13 – 14 years (Level 3)	45	.18
15+ years (Level 4)	161	.64
	Mdn (IQR)	**Range**
Subjective social status	6 (4 – 7)	1 – 10

Note. Years spent in formal education was measured on a discrete scale ranging from 0 to 20+ years and subsequently categorized into levels of qualification used by the UK Census: Level 1 (secondary school), Level 2 (secondary school completed), Level 3 (sixth form/ college completed), and Level 4 (at least one year of higher education/ university). Subjective social status was measured with the MacArthur Scale (Adler et al., 2000), where participants placed themselves on a 10-rung ladder representing where people stand in the United Kingdom (with higher rungs indicating higher subjective social status). M = mean; SD = standard deviation; Mdn = median; IQR = interquartile range. $N = 251$

5.3.2 Design

This study used a multi-level design, with all participants at the individual level evaluating the same 20 situations at the situation level in terms of eustress (dependent variable)

and its nine facets that constitute processes potentially related to eustress. In addition, all participants completed three individual difference measures at the individual level.

5.3.3 Materials

SAM^2 eustress instrument

Reflecting the SAM^2 approach, the situated eustress instrument used the 20 situations in Table 5.1 together with the 10 judgment scales in Table 5.3 to assess eustress and related processes across situations. As described earlier, situations were extracted from Kloidt et al. (2025) who evaluated the challenge levels of the situations in UK adults. The judgment scales were motivated by the Comprehensive Hierarchical construct of Eustress (CHE; Kloidt & Barsalou, 2024) and the diverse literatures on which it is based.

Table 5.3

Measures organized by eustress source, with descriptives and intraclass correlations

Measure / Item / Scale label	**Source**	***M* (*SD*)**	***ICC2***	***ICC3***	***ICC3k***
Eustress					
How much eustress do you typically experience in this situation? (none / a little / moderate / strong / very strong)	—	5.15 (2.97)	.27	.17	.81
Environmental support					
How much support from your physical and social environment do you typically receive in this situation? (none / a little / moderate / strong / very strong)	Goal	5.20 (2.74)	.17	.31	.90
Cognitive skills					
How effectively can you use your cognitive skills to achieve goals that are relevant and important for you in this situation? (not at all / slightly / moderately / strongly / very strongly)	Goal	6.42 (2.60)	.25	.19	.83
Positive affect					
How much positive affect do you typically experience in this situation? (none / a little / moderate / strong / very strong)	Goal	5.58 (3.09)	.46	.21	.84
Coping and action					

(continued on next page)

Table 5.3 (continued)

Measure / Item / Scale label	Source	*M (SD)*	*ICC2*	*ICC3*	*ICC3k*
How much can you cope and act effectively in this situation? (not at all / slightly / moderately / strongly / very strongly)	Goal	6.47 (2.53)	.13	.20	.83
Successful outcomes					
How much do successful outcomes in this situation typically help you grow? (not at all / slightly / moderately / strongly / very strongly)	Goal	5.82 (2.92)	.39	.29	.89
Connection					
When in this situation, how connected do you typically feel with others? (not at all / slightly / moderately / strongly / very strongly)	Moment	4.72 (2.95)	.30	.24	.87
Mindfulness					
When in this situation, how mindful are you typically of what's occurring? (not at all / slightly / moderately / strongly / very strongly)	Moment	6.32 (2.59)	.17	.28	.89
Fulfilment					
When in this situation, how much fulfilment do you typically experience? (none / a little / moderate / strong / very strong)	Moment	5.69 (3.14)	.46	.21	.84
Engagement					
When in this situation, how engaged are you typically with what's occurring? (not at all / slightly / moderately / strongly / very strongly)	Moment	6.56 (2.72)	.27	.21	.84

Note. The first measure is the dependent variable (eustress), followed by the nine facets extracted from the Comprehensive Hierarchical construct of Eustress (CHE; Kloidt & Barsalou, 2024). The name of each measure (bold) is followed by the item and scale labels. Participants rated all measures on continuous 0 to 10 self-report scales (one decimal place precision). The next column shows the CHE eustress source from which the facets were sampled: goal = goal-directed action, moment = momentary experience. The *ICC2* is the inter-rater agreement for each measure across the 20 situations, treating participants as random effects. The *ICC3* is the coherence of the 20 situations in ordering participants, treating situations as fixed effects. The *ICC3k* is Cronbach's alpha, capturing the measures' test reliability in ordering participants by their aggregate ratings across situations. M = mean; SD = standard deviation. $N = 251$

5.3.4 Procedure

Following recruitment on Prolific, participants were referred to the Qualtrics platform, where they provided informed consent and completed the survey online (8 February 2025). All participants then completed the CHER-Qual followed by the PSS-10, the SAM² eustress instrument, sociodemographic questions, and the SMM. As typically implemented, the order of CHER-Qual items was randomized, whereas the item order for the PSS-10 and SMM was fixed. For the SAM² eustress instrument, all participants first completed the judgment block for eustress (dependent variable); the order of the subsequent judgment blocks (facets) was randomized. Within each judgment block, the order of situations was also randomized. Following study completion (Mdn = 31 min, IQR = 24 – 40 min), participants were debriefed, redirected to Prolific, and compensated with £4.50.

5.3.5 Analysis

We performed statistical analyses in R (v4.3.2; R Core Team, 2023) with the packages tidyverse (Wickham et al., 2019), psych (Revelle, 2024), and lavaan (Rosseel, 2012). We have uploaded supplementary materials to the Open Science Framework including raw data, analysis files, and supplemental results files. They can all be accessed here: https://osf.io/62mn5/

5.4 Results

5.4.1 Hypothesis 1: Large reliable individual differences in eustress

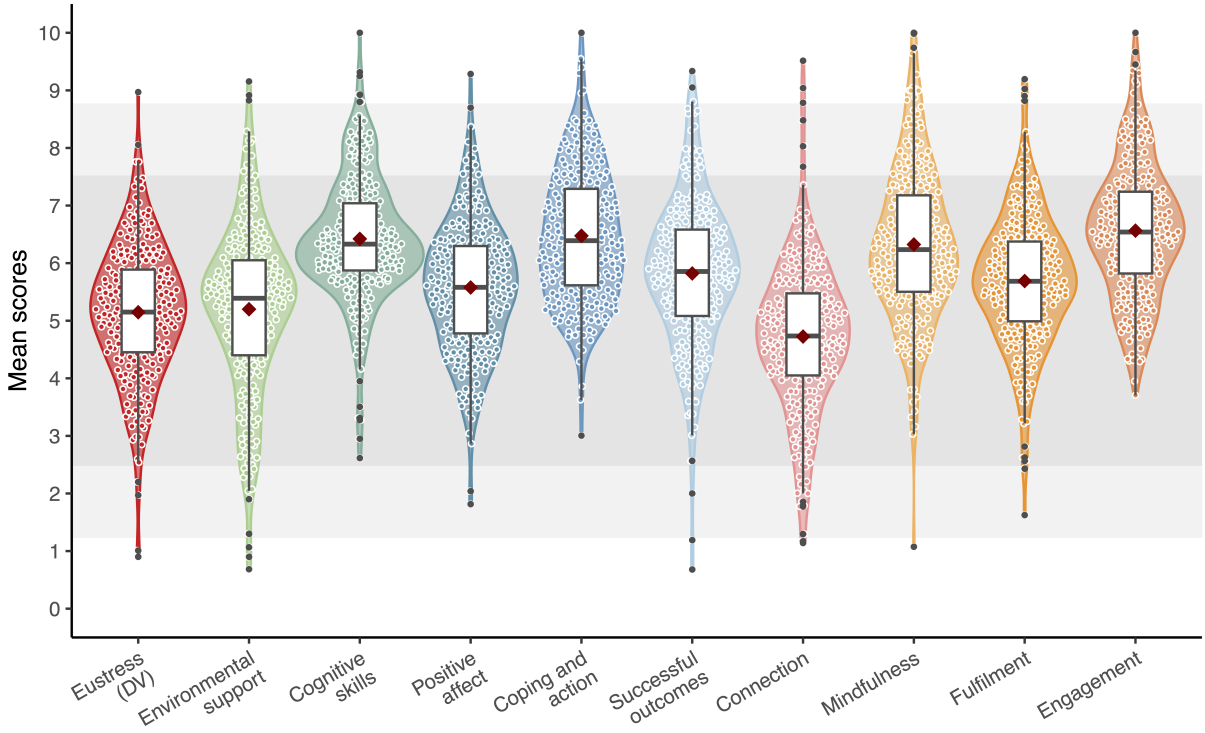
We predicted large, reliable individual differences in eustress when averaged across situations. Figure 5.2 shows each participant's mean judgment for eustress (dependent variable) and its nine facets (influential processes) across the 20 challenging situations that were assessed. As predicted, mean eustress judgments showed large individual differences ranging from 0.90 to 8.97 (M = 5.15; SD = 2.97). Whereas some individuals experienced high levels of eustress across situations, other experienced little to no eustress.

As further predicted, Table 5.3 shows that mean judgments were reliable for eustress (α = .81) and its nine facets, ranging from .83 (cognitive skills, coping and action) to .90 (environmental support). Notably, Table 5.3 also shows that the 20 situations exhibited low coherence when ordering individuals according to their eustress judgments ($ICC3$ = .17) and their nine facets ranging from .19 (cognitive skills) to .31 (environmental support). The SAM² eustress instrument thus establishes satisfactory reliability through maximizing the coverage of the construct (rather than via its saturation; Dutriaux et al., 2023). We

therefore assessed reliability using Cronbach's alpha, not with coefficient omega, which captures saturation instead.

Figure 5.2

Participants' mean judgments for eustress and its nine facets



Note. Violin plots show the distribution of participants' judgments, averaged across 20 situations. Each dot represents the mean judgment from a single participant. Boxplots show the median for a measure and its interquartile range; superimposed diamonds depict the mean. The dark grey rectangle indicates 50% of the rating scale (2.5–7.5); the light grey rectangle indicates 75% of the rating scale (1.25–8.75). $N = 251$

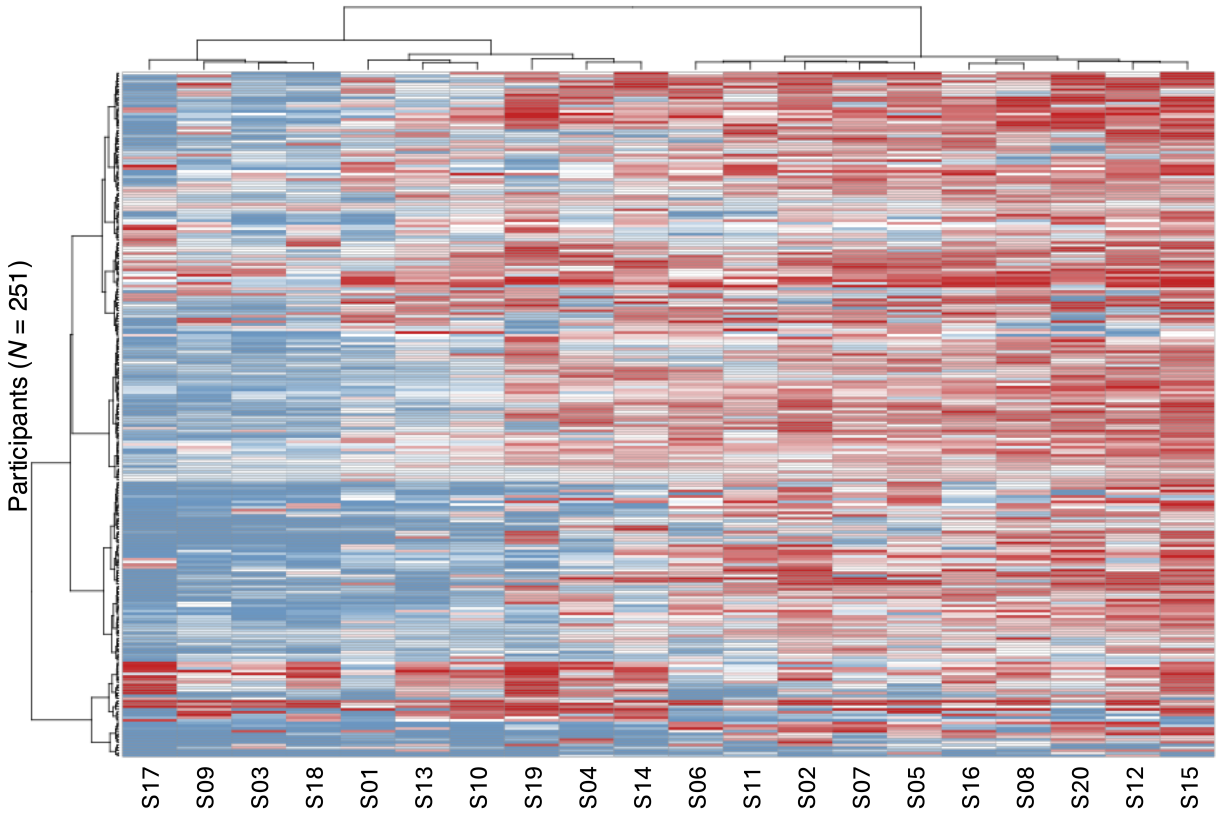
5.4.2 Hypothesis 2a and 2b: Substantial situation effects and individual-situation interactions

We predicted that individual eustress judgments would vary situation by situation rather than exhibiting constant trait levels of eustress across situations. We further predicted a large individual-situation interaction, as the level of eustress would depend not only on the situation but also on the individual.

Figure 5.3 visualizes the 5,020 eustress judgments obtained across individuals and situations as a heatmap. Each cell presents the eustress judgment from a specific participant (row) and a specific situation (column). Redder cells visualize higher eustress judgments and bluer cells lower eustress judgments. The dendrograms cluster participants and situations with similar eustress judgments.

Figure 5.3

Heatmap of 5,020 eustress judgments



Note. Each row presents the 20 eustress judgments from a participant. The index below each column indicates the corresponding situation in Table 5.1. As a cell becomes increasingly red, the eustress judgment increasingly approached 10 (on a 0–10 scale; Table 5.3). As a cell becomes increasingly blue, the eustress judgment increasingly approached 0. As a cell becomes increasingly white, the eustress judgment increasingly approached 5. Dendrograms from hierarchical Ward D clustering established groups of participants with similar eustress judgments across situations (left) and groups of situations with similar eustress judgments across participants (top). N = 251

As illustrated by highly varying cell colors within each row of Figure 5.3, participants' eustress judgments varied substantially across situations. Indeed, 53% of participants (133 out of 251) ranged from 1 to 9 in their eustress judgments, 78% (197 out of 251) ranged from 2 to 8, and 94% (237 out of 251) ranged from 3 to 7. These findings support our prediction of substantial situation effects. Additionally, at the group level, the average eustress judgments across individuals varied widely from situation to situation, ranging from low (columns on the left) to high (columns on the right).

Figure 5.3 also demonstrates that individuals varied widely in the patterns of eustress they exhibited across the same 20 situations. This individual by situation interaction for eustress judgments is reflected in the differing color patterns between different rows of the heatmap (and clusters of rows). The intraclass correlation in Table 5.3 for agreement

on eustress judgments (*ICC2*) quantifies the magnitude of this interaction, establishing the average correlation between participants in their eustress judgments across situation. As predicted, the average correlation was low (*ICC2* = .27), suggesting that participants interacted with situations considerably.

Finally, Figure 5.3 visualizes the differences in trait-level eustress between individuals shown earlier in Figure 5.2, reflected here in the overall redness/blueness of a participant's row. Supporting our predictions, the SAM^2 eustress instrument captured substantial individual and situational variability, alongside their interaction. As the other *ICC2* values in Table 5.3 indicate, large individual by situation interactions were also present for the nine CHE facets, ranging from .17 to .46.

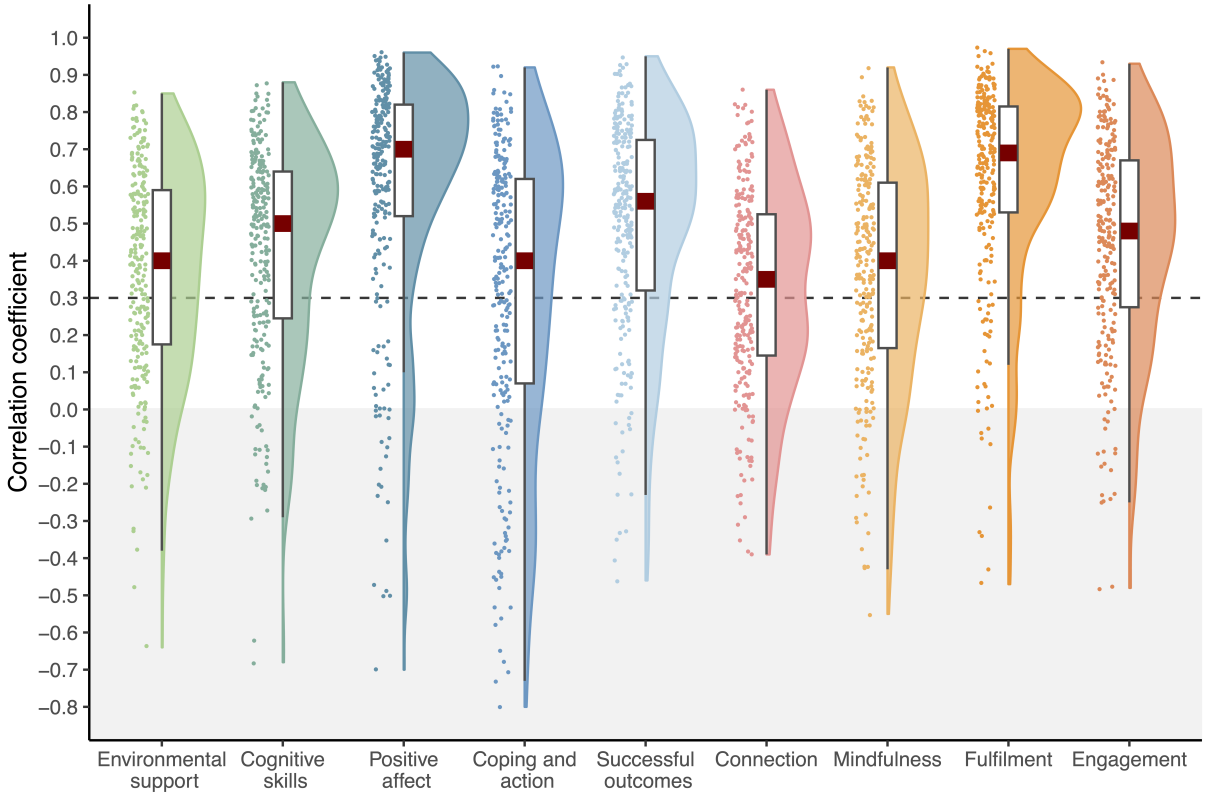
5.4.3 Hypothesis 3a and 3b: CHE's facets for goal-directed action and momentary experience predict and explain situated eustress

We expected that CHE's facets would predict eustress judgments across situations, indicated by positive and largely sized correlation coefficients between these facets and situated eustress within a given individual (> .30; Funder & Ozer, 2019; Gignac & Szodorai, 2016). To assess our hypothesis, we computed pairwise correlations between the judgments from each facet (influential process) and eustress (dependent variable) for one participant at a time. Following our preregistered assumption checks, we used Spearman correlations. To determine general patterns across our sample, we then computed the median of these pairwise correlations between eustress and each facet across all individuals. Figure 5.4 depicts the pairwise correlations for each facet in a given participant as dots, and the median pairwise correlations for each facet across participants as red segments within boxplots.

Figure 5.4 shows that, in line with our prediction, all nine facets depicted large median correlations with eustress (> .30) that differed significantly from zero at $p < .001$ (established by one-sided Wilcoxon signed-rank tests). Across our sample, situated eustress correlated most strongly with positive affect (.70) and fulfilment (.69), suggesting that experiencing eustress is closely related to feeling excited, motivated, and fulfilled in the challenging situation. In contrast, the weakest (yet still large) correlation with eustress was observed for connection (.35), followed by environmental support, mindfulness, and coping and action (.40 for all). These results perhaps reflect that not all eustress-inducing challenges lend meaningful opportunities for connecting and coping with the social and physical environment.

Figure 5.4

Predictive Spearman correlations of the nine CHE facets with eustress



Note. Scatter plots show the predictive correlation for a single participant, averaged across 20 situations. Half violin plots visualize the distribution of all participants. Boxplots show the group-level correlations, including the median (red segment) and the interquartile range (box). The dashed y-intercept depicts the cut-off for a large correlation ($\rho = .30$; cf. Funder & Ozer, 2019; Gignac & Szodorai, 2016), the grey rectangle indicates negative correlations. Median correlations were significantly different from zero for all nine facets ($p < .001$), established by one-sided Wilcoxon signed-rank tests. $N = 251$

Similar to what we saw earlier in Figure 5.2, individuals varied widely in how strongly each facet correlated with the dependent variable, reflecting large individual differences. Interestingly, the spread of correlation coefficients was most pronounced for coping and action—the facet with the highest mean judgments in Figure 5.2. This may indicate that although participants employ numerous coping and acting strategies, these may not always be successful at producing eustress. Alternatively, participants' coping may be so effective that they don't experience any type of stress in the situation (transitioning from eustress to no stress).

Having determined the prospective relationship between each facet and eustress, we next investigated how comprehensively the nine facets explain each participant's eustress judgments. To do so, we established the amount of variance in eustress judgments that a

simple linear regression with fixed main effects for all facets explained for one participant at a time. The median individual variance explained across these individual regressions was 82.80% (IQR = 73.53%–89.17%), suggesting that the nine CHE facets capture situated eustress comprehensively. The amount of variance explained was substantially higher on the individual level than on the group level, either for a simple group-level regression (R^2 = 46.92%) or a group-level linear mixed effects model with random intercepts for participants and situations (R^2 = 52.79%). These differences are not surprising given the large individual variability in predictive strength that we saw in Figure 5.4. In line with Hypotheses 3a and 3b, the group-level correlations and individual-level regressions comprehensively predicted and explained eustress judgments, suggesting high construct and content validity of the SAM^2 eustress instrument.

5.4.4 Hypothesis 4: Low correlations between situated eustress and trait-level measures

We predicted small-to-medium correlations ($< |.30|$; Funder & Ozer, 2019; Gignac & Szodorai, 2016) between eustress from the SAM^2 eustress instrument (each participant's mean eustress across situations) with trait-level measures for eustress (CHER-Qual; Kloidt & Barsalou, 2026), adaptive stress mindsets (SMM; Crum et al., 2013), and distress (PSS-10; Cohen et al., 1983). Again, we used Spearman correlations because pairs of variables violated the necessary assumptions for Pearson tests. In addition to our confirmatory analyses, we explored the relationship between situated eustress and its situated CHE sources. To do so, we computed the mean judgment for each participant across situations for all facets belonging to goal-directed action (environmental support, cognitive skills, positive affect, coping and action, successful outcomes) and momentary experience (connection, mindfulness, fulfilment, engagement). We assessed the significance level of all exploratory correlations using Bonferroni correction at $p < .004$ ($\alpha = .05/12$).

As Table 5.4 illustrates, the pairwise correlation between situated and trait eustress was larger than predicted, $\rho = .36$ ($p < .001$), suggesting that dynamically changing states of eustress showed a clear association with individuals' general disposition of eustress across all types of challenging situations. SAM^2 eustress, however correlated more strongly with the CHE sources of goal-directed action ($\rho = .51$, $p < .004$) and momentary experience ($\rho = .52$, $p < .004$) that also vary dynamically across situations.

The pairwise Spearman correlation of SAM^2 eustress with a stress-is-enhancing mindset was .17 ($p < .01$), supporting our prediction that individuals' eustress judgments in real-life situations show only a small association with their general belief that stress enhances outcomes across various areas of life. In contrast to our prediction, the pairwise Spearman correlation between situated eustress and trait-level distress was insignificant –.09 (p = .137), indicating that the two measures are not related. Notably, however, we observed a

large pairwise correlation between trait eustress and trait distress ($\rho = -.57$, $p < .004$). This suggests that the absence of a correlation between SAM^2 eustress and PSS-10 distress likely reflects differences in measurement (situated vs. unsituated) rather than construct independence.

Table 5.4

Spearman correlations with related constructs

	SAM^2 Eustress	**SAM^2 Goal**	**SAM^2 Moment**	**CHER-Qual**	**PSS-10**
SAM^2 Eustress	–				
SAM^2 Goal	$.51^{a}$	–			
SAM^2 Moment	$.52^{a}$	$.77^{a}$	–		
CHER-Qual	$.36^{***}$	$.50^{a}$	$.46^{a}$	–	
PSS-10	–.09	$-.29^{a}$	$-.20^{a}$	$-.57^{a}$	–
SMM	$.17^{**}$	$.22^{a}$	$.16^{b}$	$.21^{a}$	$-.17^{a}$

Note. Spearman correlations between participants' situated judgments for eustress (SAM^2 Eustress), goal-directed action (SAM^2 Goal), momentary experience (SAM^2 Experience), trait eustress (CHER-Qual), trait distress (PSS-10), and stress-is-enhancing mindsets (SMM). Significant correlations for one-sided confirmatory predictions are marked with $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. For two-sided exploratory analyses with Bonferroni correction ($\alpha = .05/12$), significant correlations are marked with a $p < .004$; non-significant correlations are marked with $^{b}p \geq .004$. $N = 251$

5.4.5 Discovery: Latent structure of the CHE facets

In a discovery analysis, we addressed whether facets from the same CHE source of eustress load onto a common factor. Because Table 5.4 exhibited sizeable correlations between all three sources of CHE, we not only included the nine situated CHE facets from the SAM^2 instrument but also computed scores for the four remaining CHE facets from the CHER-Qual subscale (resilience, internal competencies, interpersonal skills, well-being). For the situated facets, we calculated each participant's mean judgment across situations. For the unsituated facets, we calculated each participant's mean judgment across all CHER-Qual items belonging to the same facet (see Figure 5.1 for the hierarchical structure).

Following an analysis pipeline developed in an earlier article that assessed the CHE model using an unsituated instrument (Kloidt & Barsalou, 2026), we performed a series of factor analyses on our facet data (fully reported in the Supplemental Materials). We first ran three confirmatory models: (1) all facets load onto a general eustress factor (a unidimensional model), (2) the facets load onto three separate factors reflecting CHE's

respective sources (a multidimensional model), and (3) each facet loads onto a general eustress factor and its respective source factor (a bifactor model).

All confirmatory factor solutions presented with non-acceptable model fit, indicating a misspecification of the factor loading structure (again, fully reported in the Supplemental Materials). We therefore conducted two exploratory factor analyses (EFAs) where facets could load freely onto three latent factors (resembling the multidimensional model) or onto a general factor and three group factors (resembling the bifactor model). Compared to the confirmatory models, both EFAs presented with satisfactory model fit and adjusted yet meaningful facet loading structures. Here we focus on the best-fitting exploratory bifactor model and report the three-factor EFA in the Supplemental Materials.

The exploratory bifactor model with orthogonal factors accounted for 58.98% of shared variance and provided satisfactory model fit, CFI = .971, TLI = .928, RMSEA (90% confidence interval) = .074 (.053 – .096). As Figure 5.5 illustrates, the "general eustress" factor received meaningful loadings > .30 from all facets, including strongest loadings from successful outcomes (.80), positive affect (.79), and fulfilment (.78). The general factor accounted for 64.98% of the explained variance, demonstrating that the 13 CHE facets captured a dominant, general construct of eustress, similar to what we found in our earlier study (Kloidt & Barsalou, 2026).

The three group factors captured residual variance in the facets after the general factor first accounted for common variance across all items. The group factor "stable qualities" represents its respective CHE source by receiving main loadings > .30 from its associated facets internal competencies (.71), wellbeing (.54), resilience (.48), and interpersonal skills (.38). "Stable qualities" also received a sizeable cross-loading from coping and action, perhaps suggesting that individuals routinely apply coping skills in challenging situations. "Stable qualities" accounted for 17.59% of explained variance, indicating that, in our model, the general factor may benefit from an additional group factor on trait eustress.

The second group factor "engaging mentally" received meaningful loadings > |.30| from engagement (.40), cognitive skills (.34), mindfulness (.34), coping and action (.33), and successful outcomes (–.31). By emphasizing the use of mental skills in the situation rather than anticipating desired outcomes, "engaging mentally" accounted for 8.80% of explained variance. The third group factor "feeling supported and connected" received sizeable loadings from environmental support (.61) and connection (.42), accounting for 8.62% of explained variance. Notably, the group factors "engaging mentally" and "feeling supported and connected" deviated from CHE's sources of goal-directed action and momentary experience. "Engaging mentally" emphasized internal processes whereas "feeling supported and connected" emphasized interconnections with the physical and social environment.

Figure 5.5

Factor loading plot for exploratory bifactor model

Note. The exploratory bifactor model with orthogonal factors accounted for 58.98% of total variance with most variance explained by "general eustress" (64.98%), followed by "stable qualities" (17.59%), "engaging mentally" (8.80%), and "feeling supported and connected" (8.62%). The facets are color-coded by CHE source: goal-directed action (green/blue), momentary experience (orange/pink), and stable qualities (purple). Factor loadings $\geq |.30|$ are bolded and distinguished by dashed lines. Light gray rectangles distinguish negative factor loadings. $N = 251$

Analogous to Hypothesis 4, we investigated whether factor scores from the exploratory bifactor model predicted eustress across our sample. Spearman correlations with two-sided, Bonferroni-corrected significance testing ($\alpha = .05/4$), exhibited a large pairwise correlation between SAM^2 eustress and "general eustress" ($\rho = .61$; $p < .013$). In contrast, SAM^2 eustress was uncorrelated to "stable qualities" ($\rho = .03$; $p = .587$), "engaging mentally" ($\rho = -.08$; $p = .181$), and "feeling supported and connected" ($\rho = .10$; $p = .100$). These results are not surprising, given that group factor scores in a bifactor model represent residual variance between subgroups of facets after first contributing to common variance for the general factor. Additionally, each group factor only received meaningful loadings from a few facets whereas weakly-loading and cross-loading facets may have created noise. Overall, the results from our discovery analyses suggest that facets from all sources of the CHE model measure a dominant, general eustress factor that strongly correlates with eustress in situations where it occurs.

5.5 Discussion

We used the Situated Assessment Method (SAM^2; Dutriaux et al., 2023) to investigate eustress in real-life challenging situations and to explore how a variety of situational and individual processes are related to it. Across the 20 situations assessed, our sample of UK adults exhibited moderate levels of eustress. As predicted by Hypothesis 1, trait-levels of eustress across situations varied substantially between individuals, suggesting large individual differences (Figure 5.2) that exhibited satisfactory test reliability (Table 5.3).

In addition to individual differences, the SAM^2 approach established large differences between situations (Figure 5.3). As predicted by Hypothesis 2a, some situations exhibited relatively high levels of eustress (e.g., S15 "Try to close a big deal at work and receive a significant bonus"), whereas others exhibited relatively low levels (e.g., S09 "Deal with a parking fine for overstaying in a parking spot"). As predicted by Hypothesis 2b, a large individual by situation interaction emerged for eustress (Table 5.3), indicating that individuals experience eustress in the same 20 situations quite differently. These results demonstrate that both situation effects and individual-situation interactions are relevant when assessing eustress.

As predicted by Hypothesis 3a, situated eustress judgments correlated strongly with the nine situated CHE facets for goal-directed action and momentary experience (Figure 5.4), suggesting high construct validity of the SAM^2 eustress instrument. At the group-level, eustress most strongly correlated with experiencing positive affect and fulfilment in challenging situations. Conversely, the lowest median pairwise correlations were related to environmental support, connection, mindfulness, and coping and action, potentially because not all eustress-inducing situations assessed here allowed for interactions with the physical and social environment.

Interestingly, the spread of correlation coefficients was most pronounced for coping and action, the facet that received the highest mean judgments (Figure 5.2). These results may indicate that individuals are not always successful when trying to cope with a challenge (failure to pivot from distress to eustress). Alternatively, perhaps some individuals may cope and act so successfully that they don't experience any type of stress (pivot from eustress to no stress). Because we only measured one type of stress (eustress) in a correlational design that does not justify causal conclusions, these possibilities constitute a potential topic for future research.

As predicted by Hypothesis 3b, the nine situated CHE facets explained high levels of variance in situated eustress judgments, suggesting high content validity of the SAM^2 eustress instrument. At the group level, CHE's facets explained around 47% of the variance. At the individual level, the facets explained a substantially higher 83%, likely accounting for large individual differences that attenuated the prediction at the group level. These

results indicate that the SAM^2 eustress instrument captures the content of eustress comprehensively.

The relations between situated eustress and unsituated individual differences measures only partially supported Hypothesis 4. Situated and trait-level eustress (CHER-Qual; Kloidt & Barsalou, 2026) correlated more strongly than expected, providing evidence for the construct validity of the SAM^2 eustress instrument (Table 5.4). As predicted, eustress in real-world situations exhibited a small positive correlation with general mindsets that stress is enhancing (SMM; Crum et al., 2013). In contrast with our expectations, situated eustress and trait distress (PSS-10; Cohen et al., 1983) were uncorrelated, likely reflecting differences in measurement (situated vs. unsituated) instead of conceptual independence.

Lastly, in a discovery analysis, we investigated the factor loading structure of the situated CHE facets from SAM^2 (goal achievement, momentary experience) and the four remaining, unsituated CHE facets for stable qualities (resilience, interpersonal skills, internal competencies, wellbeing) from the CHER-Qual. We identified a general latent factor that meaningfully captured all CHE facets, accounted for 65% of the explained variance, and strongly correlated with situated eustress. The "general eustress" factor resulted from an exploratory bifactor model that also included three group factors (Figure 5.5). Whereas the group factor "stable qualities" reflected the loading structure proposed by the CHE model, the other group factors "engage mentally" and "feeling supported and connected" deviated from theory yet only accounted for a small proportion of explained variance.

5.5.1 Theoretical implications

Our results suggest that multiple influences underlie eustress, including interactions between individuals and situations, coping, fulfilment, and successful outcomes. Our findings closely align with the transactional model of stress, suggesting that all types of stress responses (including eustress) are influenced by large individual-situation interactions (Lazarus & Folkman, 1984; Lazarus & Folkman, 1987). Only focusing on individual-level trait measures of eustress masks considerable individual-specific variability at the situation level (Dutriaux et al., 2023; Fleeson & Jayawickreme, 2021). Conversely, because different individuals experience different patterns of eustress across the same situations, the situation alone is not the sole cause of their stress experience (Bandura, 1978; Cervone et al., 2001; Mischel & Shoda, 1995).

Our results further support the Comprehensive Hierarchical construct of Eustress (CHE; Kloidt & Barsalou, 2024). Our finding that all influential processes predict eustress on the group level and the individual level, supports CHE's sources of state eustress (goal-directed action and momentary experience) from which they were extracted. In other words, situational processes from the CHE model predicted and explained dynamically changing states of eustress across diverse, real-world challenging situations. Our finding

that situated eustress strongly correlated with the CHER-Qual indicates that trait-like dispositions from the CHE model also showed meaningful associations with situated eustress. Combining situational and trait-like processes into an exploratory bifactor model revealed a dominant general eustress factor that meaningfully captured all facets from the CHE model and, again, strongly correlated with eustress in situations where it occurs.

Whereas the exploratory bifactor model supports the content of CHE, the loading structures of two group factors deviated from CHE's state-level sources of goal-directed action and momentary experience. Specifically, "engaging mentally" and "feeling supported and connected" clustered facets that emphasized internal versus external processes related to eustress, respectively. Notably, these factors differ from those in CHE, which instead clustered these facets on goal achievement and momentary experience. Although the group factors in question only accounted for about 17% of explained variance, these findings put into question whether a situated instrument should operationalize eustress somewhat differently compared to an unsituated instrument where the hierarchical structure of CHE was replicated (Kloidt & Barsalou, 2026).

5.5.2 Measurement implications

As for any other behavior, eustress can be operationalized in an unsituated study design—measuring traits—or in a situated study design—measuring dynamic states that can be averaged to signify traits. Whereas previous research has tested and confirmed the CHE model with an unsituated design (asking individuals to average their experiences across all challenging situations in their lives; Kloidt & Barsalou, 2026), this study investigated eustress and its state-level processes with a situated design (asking individuals to judge a diverse set of real-life challenging situations).

Both types of study design suggest that eustress is best explained by a bifactor model with a dominant general factor and three complementary group factors. The loading structures for two of the group-level factors differed between study designs but did not explain much additional variance compared to the general group factor that was most important. These results indicate that in both an unsituated and a situated study design, eustress can be measured as a general construct using one subscale (similar to general intelligence assessments; Deary, 2012). If of interest, researchers could include additional subscales to measure specific types of eustress (similar to specific types of intelligence; Deary, 2012). Here, different subscales may be useful for different study designs: In the unsituated instrument, the "goal-directed action" group factor explained most additional item variance, thus, seems most relevant for complementing the general eustress factor that focuses on momentary engagement and positive qualities (Kloidt & Barsalou, 2026). In our situated study design, the "stable qualities" group factor explained most additional item variance, thus, seems most relevant for complementing the general eustress factor

(that focuses on state-level influences).

The notion that situated vs. unsituated measurements capture related but not the same information has been observed across various behaviors (Dutriaux et al., 2023; Taylor Browne Lūka et al., 2024). Our findings therefore highlight the need for nuance when measuring eustress, recognizing that complex interactions of multiple processes govern real world behavior (Barsalou, 2019).

5.5.3 Applied implications

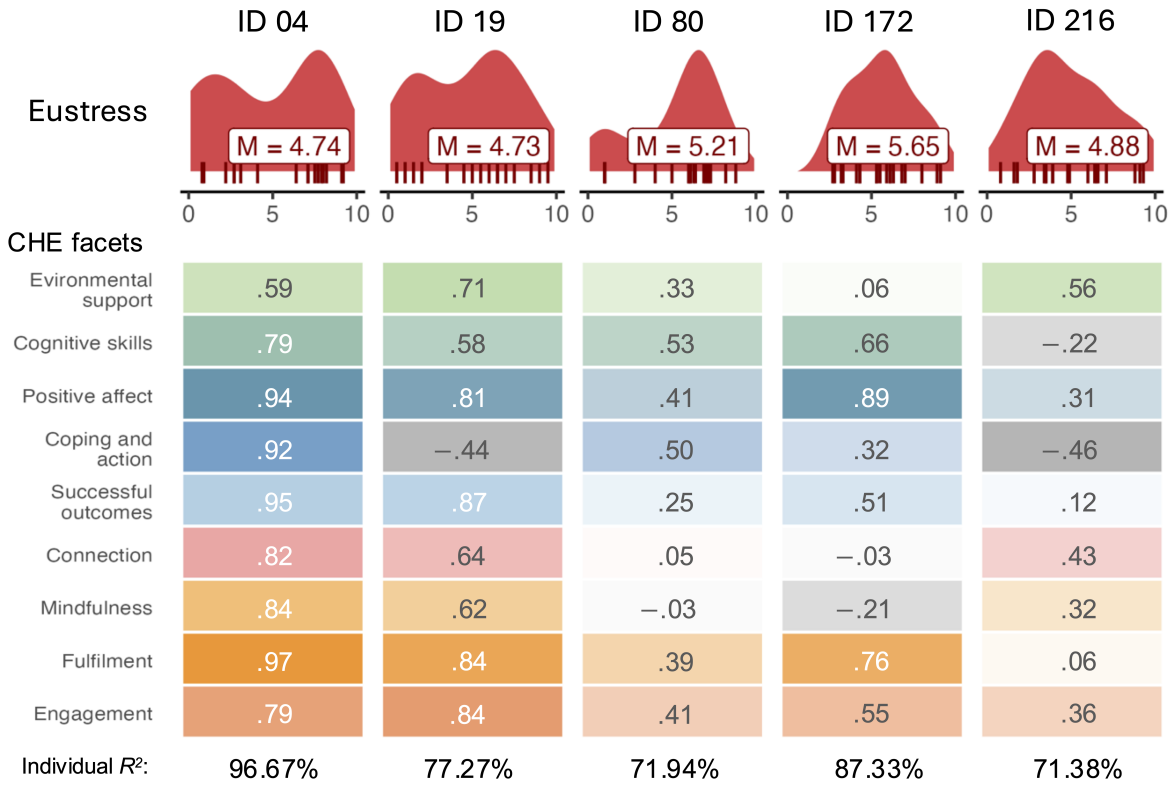
Individual-level predictive profiles from the SAM^2 approach could be used to identify facets that most likely foster eustress in a personalized intervention (Dutriaux et al., 2023). Figure 5.6 illustrates such predictive profiles for five participants from this study. For each participant, the upper panel presents their distribution of eustress judgments across the 20 situations (dark-red tiles), illustrating their general disposition to eustress (labels). The lower panel illustrates the pairwise Spearman correlations between each participant's eustress judgments and the nine CHE facets. The individual R^2 shows the variance that the facets combined explained in each individual's eustress judgments across situations.

All participants in Figure 5.6 present with moderate eustress levels that could be increased if desirable. If, for example, eustress is positively and strongly associated with all situated CHE facets (participant 4), then strategies to enhance any facet could help enhance eustress. If eustress exhibits different combinations of positive, negative, and negligible correlations with CHE facets (participants 19, 80, 172, 216), then strategies to enhance the facets with large positive correlations could be targeted specifically in an individualized intervention (e.g., environmental support for participant 216).

The SAM^2 approach could also help identify challenging situations with the highest eustress potential (Dutriaux et al., 2023). A contextualised intervention could then identify what processes foster eustress for whom in these situations (Craig et al., 2018). Coping and action, for instance, may be a highly useful skill in challenging situations that the individual has control over (e.g., S05 "Try to cook a new recipe with many steps for the first time") but less useful, and potentially frustrating, in less controllable situations (e.g., S07 "Handle a surprise visit from an old friend gracefully"). Again, predictive eustress profiles may offer insights into useful skills on the group level (Figure 5.4) and the individual level (Figure 5.6).

Figure 5.6

SAM^2 predictive eustress profiles for five participants



Note. Each column presents the predictive profile of an individual participant. The upper panel presents the eustress judgments as distribution (density plot), situation-specific judgments (tile plots), and means across situations (superimposed label). The lower panel illustrate the pairwise Spearman correlations between the participant's eustress judgments and the nine CHE facets. The individual R^2 shows the variance that the facets combined explain in eustress judgments of the individual. CHE = Comprehensive Hierarchical construct of Eustress; *ID* = identification number; M = mean; R^2 = total variance explained

5.5.4 Limitations and further directions

A key limitation of our research approach is that the results are correlational and should not be used in isolation to inform causal explanations of eustress (Diener et al., 2022; Grosz et al., 2020). Our results do not provide insights into the mechanisms by which the nine CHE facets affect eustress, nor how eustress affects the nine CHE facets. Still, our results provide evidence that these facets (and underlying sources) are likely relevant to our theoretical understanding of eustress. Researchers could therefore expand upon our findings by manipulating these facets and observing the effects, if any, that they have on eustress.

Another limitation of our research is that it is situated in the UK context, such that the situations we identified may not be comprehensive or relatable in other contexts.

To the extent that different populations experience eustress in different contexts, the situations in Table 5.1 need to be adjusted. The generalizability of our research is further limited by our non-probabilistic sample design, i.e., participants were recruited without information about selection probabilities (Heeringa et al., 2017). Because our measurement models are only partially independent from our sample, our results may not generalize towards our target population, even though the sample characteristics approximated UK adult population averages. Future research could therefore use SAM^2 to identify relevant situations for other target populations, explore variations in eustress facets across these different contexts, and collect data from probabilistic samples allowing for more robust and generalizable inferences.

A final limitation of this research is the potential of measurement error in our eustress measures, given it relied on self-report judgments. Participants may be unable to provide accurate self-reports about their eustress because they lack a detailed understanding of the construct and/or conscious access to relevant thoughts and feelings (Corneille & Gawronski, 2024). Whereas participants received descriptions for eustress and its nine facets, future research could gain more detailed insights into individuals' understandings of positive stress using qualitative methods. Although our situated assessment aimed to help participants access situation-specific, relevant memories from their daily life (cf. Dutriaux et al., 2023), future research could also measure eustress in real-time using ecological momentary assessments.

5.6 Conclusion

We used the SAM^2 to investigate complexities in eustress—the positive experience of a challenging situation—focusing on individual and situational variability and underlying sources of eustress. Our results highlight substantial individual-situation interactions that align with transactional models of stress. Situational processes from the Comprehensive Hierarchical construct of Eustress (CHE) predicted individuals' eustress judgments across situations whereas trait-level CHE processes strongly correlated with averaged eustress judgments. Exploratory analyses suggest that situated eustress can be best measured by a dominant general factor, whereas rich descriptive profiles from our multi-level data can inform personalized and context-sensitive interventions to foster eustress when desirable. The study's correlational design, however, limits causal inferences; the UK context limits generalizations of our findings; and self-report judgments may introduce measurement error. Future research could build on our findings by manipulating facets like coping or fulfilment to assess their causal effect on eustress or could use SAM^2 to identify predictive profiles across challenging contexts with high eustress potential.

Chapter 6

General discussion

6.1 Overview

Across four projects, we investigated how individuals experience eustress in challenging situations and what factors influence its manifestations. In Project 1, we established a unified and well-defined construct, CHE, that proposes three main sources of eustress: successful goal-directed action, fulfilling momentary experiences, and positive stable qualities of the individual. In Project 2, we found that the CHE model adequately described eustress in UK adults and provided insights into its relationships with distress and wellbeing. In Project 3, we established feature profiles of 20 difficult situations from a UK context and found that as a situation becomes more threatening and challenging, it becomes more difficult and effortful with a less obvious solution and less effective coping. In Project 4, we found that eustress emerges from individual-situation interactions, is predicted by the underlying processes of the CHE model, and is weakly related to adaptive stress mindsets. By establishing a comprehensive construct of eustress and testing it across individuals and situations, this thesis may help formalize the small but growing research field on positive stress. We suggest that our research can be used to establish who experiences eustress under what circumstances, and what strategies are most effective in fostering positive stress where desirable and applicable. By doing so, we hope that this thesis may contribute to a more balanced discourse on stress. We will next present a summary of the key findings of this thesis, its overall contributions, the implications of its results, the limitations of the research, and further research directions for this approach.

6.2 Summary of key findings

The aim of Project 1 (Chapter 2) was to empirically develop a unified and well-specified construct of eustress and evaluate the diverse eustress literatures that contributed to it. Our scoping review of 80 articles identified 57 unique features of eustress that we

synthesized into a Comprehensive Hierarchical construct of Eustress (CHE). According to CHE, eustress emerges from three main sources: (1) successful goal-directed action, (2) experiencing the moment in an enjoyable and fulfilling manner, and (3) positive stable qualities of the individual. Within in the three sources, CHE established 13 specific facets of eustress hierarchically, which in turn organize the remaining 47 eustress features.

Our results suggest that rather than taking a single form, eustress manifests itself as diverse states during successful goal-directed action and fulfilling momentary experience. Regularly producing eustress in these manners likely establishes CHE's stable qualities for generating eustress effectively on future occasions. Interestingly, the stable qualities associated with eustress were closely related to traits associated with wellbeing (Friedman & Kern, 2014; Ruggeri et al., 2020), suggesting a link between positive experiences in challenging versus non-challenging situations.

In Project 2 (Chapter 3), we tested the CHE model and established how UK adults experience eustress in general across the challenging situations in their lives. We developed a novel eustress instrument–the Comprehensive Hierarchical Eustress Review (CHER)–that contained three subscales for CHE's three sources of eustress and 47 items that reflected CHE's 47 features. We found that items from all subscales loaded together on a general eustress factor and that items from the same subscale simultaneously loaded together on three group factors. The general eustress factor correlated negatively with distress ($\rho = -.50$) and positively with psychological wellbeing ($\rho = .62$). We also identified four clusters of participants with different eustress profiles (e.g., eustress minimalists), who further differed on sociodemographic characteristics and personality traits.

These results support the CHE model in two ways: First, the presence of a general factor indicates that eustress forms a coherent construct. Second, the further presence of three group factors, reflecting CHER subscales, supports the three sources of eustress identified in CHE. The negative correlation with distress suggests that positive and negative stress are related but not simple inverses of another. The positive correlation with psychological wellbeing supports the proposed link between positive experiences in challenging vs non-challenging situations. Finally, the latent eustress profiles in our sample could help develop eustress interventions tailored to different segments of the population.

For Project 3 (Chapter 4), we normed 20 difficult situations by asking UK adults to judge each situation on dimensions of threat, challenge and eight related features (e.g., anticipated loss). In a preregistered study, we found that the eight features explained high levels of variance in threat (71%) and challenge (96%) which exhibited, surprisingly, very similar correlational patterns, suggesting that features associated with difficult situations and the process of coping with them are common to both. Speculatively, we proposed that the primary difference between threat and challenge may be affective valence, a proposal that awaits further empirical assessment. Contrary to what we expected to see, threats

and challenges appear to share more similarities than differences

Additionally, we identified four clusters of situations (e.g., challenging but rewarding) that characterize real-life stressors with various feature combinations. When judging situations with an open-source LLM, we found that the LLM judgments matched with human judgments at the aggregate level, but that the LLM judgments failed to capture structural relationships between features well, with many errors.

For Project 4 (Chapter 5), we combined insights from previous projects to assess how eustress varies across individuals and situations simultaneously, and how well previously defined processes predict and explain it. In a preregistered study, UK adults judged their eustress across 20 challenging situations (Project 3), along with nine influential processes (e.g., coping, fulfilment), reflecting CHE's facets for state eustress (Project 1). Our multilevel data showed reliable individual differences, substantial situation effects, and large individual-situation interactions in eustress judgments. The nine influential processes correlated strongly with situated eustress, explaining a median variance of 83% in individual-level regressions. Situated eustress correlated with external measures of trait eustress (ρ = .36) and stress-is-enhancing mindsets (ρ = .17) but, interestingly, was unrelated to trait distress (ρ = –.09).

Our results suggest that neither individuals nor situations alone, but also their interactions, determine positive stress experiences. Our finding that all situational processes predicted eustress further supports the importance of CHE's sources of state eustress–goal-directed action and momentary experience–from which they were extracted. Our finding that situated eustress strongly correlated with trait eustress supports the notion that eustress states and traits influence another. The correlation between situated eustress and stress-is-enhancing mindsets indicates a small relation between a general disposition related to stress and lived experiences of eustress. Conversely, our finding that situated eustress and trait distress were unrelated could indicate that the two constructs are unrelated for perhaps interesting but not yet understood reasons, although difference in measurement methods (situated and unsituated) could also be responsible as well.

Overall, this thesis highlights the complexity of positive experiences in challenging situations: Eustress can manifest as a state or trait with many associated facets and features that individuals experience differently. Difficult situations differ in their potential for threat and challenge, and, ultimately, interactions between the individual and their challenging environments underlie eustress responses. This thesis also highlights the potential of eustress as an antidote to distress, a boost for wellbeing, and a habitual response to adaptive stress mindsets.

6.3 Overall contributions and implications

6.3.1 Theoretical contributions

As described in the general introduction, eustress research remains in early stages of theory development. To strengthen the field and allow for a greater understanding, this thesis intended to support the development of a basic eustress theory for informative hypothesis testing (Dubin, 1978; Scheel et al., 2021). Moving from a theoretical framework to experimental testing can be seen as a sequence of theoretical and auxiliary premises, also referred to as the "derivation chain" (Meehl, 1990). The research presented in this thesis provides initial evidence for several elements of this derivation chain, including construct development, construct measurement, relationships between constructs, and their boundary conditions (Scheel et al., 2021). We note that the elements and evidence presented here are not exhaustive but simply offer, what we hope is, a robust point along the trajectory of eustress research.

Construct development

During construct development, researchers define the building blocks of theories and specify their attributes (e.g., Hempel, 1966). To do so, our research developed the first basic research model of eustress by integrating fragmented conceptualizations across diverse literatures (Project 1). In subsequent studies, we found that the CHE model poses two essential characteristics of good concepts. First, the CHE model is coherent because its features (Project 2) and facets (Project 4) loaded onto a single dominant eustress factor, and thus shared a substantial amount of variance. Second, as proposed by the transactional model of stress (Lazarus & Folkman, 1984), the CHE model remains differentiated from other elements of the stress response. Although eustress is related to individual-level and situation-level processes, their interactions also contribute to eustress responses (Project 4). This thesis therefore provides initial evidence for a coherent and differentiated construct of eustress that integrates insights from diverse literatures.

Measurement

To empirically examine constructs, researchers need to specify how they will be measured and understand what these measures mean (Flake & Fried, 2020). Although few eustress instruments exist (e.g., Cavanaugh et al., 2000; O'Sullivan, 2011; Rodríguez et al., 2013; Vikoler et al., 2024), they typically restrict their focus to specific populations (e.g., students), contexts (e.g., workplace settings), and tend to measure eustress as a general concept that is abstracted across all relevant challenging situations (e.g., "How often do you deal with successfully with irritating academic hassles"; O'Sullivan, 2011). Whereas

eustress can be operationalized in an unsituated study design measuring stable traits, it can also be operationalized in a situated study design measuring dynamic states that can be averaged to estimate traits. This thesis therefore developed and evaluated two CHE-based instruments: The Comprehensive Hierarchical Eustress Review (CHER; Project 2) measures eustress in individuals using CHE's 47 low-level features, whereas the Situated Assessment Method for eustress (SAM^2 eustress; Project 4) is a multi-level measurement instrument, assessing individuals' eustress and 13 CHE facets for state eustress in a set of 20 challenging situations. Whereas CHER only measures individual variation in eustress, SAM^2 eustress also measures situation variation as well, along with the interaction between individuals and situations.

Our findings indicate that both instruments reliably measure a general construct of eustress that explains substantial variance across all test items. Whereas the general eustress construct from the CHER instrument most strongly emphasizes momentary engagement and positive internal qualities, the general eustress construct from the SAM^2 instrument reflects eustress as a dynamically changing state. The notion that situated vs. unsituated measurements capture related but not the same information has been observed across various behaviors (Dutriaux et al., 2023; Taylor Browne Lūka et al., 2024), highlighting the need for nuance when measuring eustress.

Relationships between constructs

Once a construct has been defined and measured, researchers need to specify how it relates to other constructs (Scheel et al., 2021). This thesis aimed to describe relations between eustress and the adjacent constructs of distress, wellbeing, and stress mindsets. In Project 2, eustress and distress exhibited a negative correlation, yet the magnitude of the relation was moderate, suggesting that the constructs are not inverses of another. In Project 4, we found that situated eustress and trait distress were unrelated. Although the absence of a relation could reflect differences in measurement (state versus trait level), it may further indicate that eustress and distress are not inverses of each, having different featural and structural properties. Thus, in line with the transactional model of stress (Lazarus & Folkman, 1984) and the holistic stress model (Simmons & Nelson, 2007; Simmons et al., 2024), eustress and distress may be best described as parallel processes.

We also investigated the relations of eustress with wellbeing and stress mindsets. In Project 2, we found that eustress and psychological wellbeing exhibited a large positive correlation, likely reflecting the substantial conceptual overlap between eustress traits and wellbeing traits (Friedman & Kern, 2014; Ruggeri et al., 2020). In Project 4, we found a modest correlation between state eustress and stress-is-enhancing mindsets. An exploratory analysis also revealed a modest correlation between *trait* eustress and stress-is-enhancing mindsets. These findings suggest that a positive general disposition towards

stress may be weakly linked with dynamically changing eustress states and stable eustress traits. Although our findings provide valuable insights into relations of eustress with distress, wellbeing, and adaptive stress mindsets, the results presented are correlational and do not allow for causal inferences (see 6.4 Limitations). Because the goal of a robust theory is to specify causal models (Scheel et al., 2021), we outline this possibility in 6.5 Future research directions.

Boundary conditions

In addition to defining a coherent, differentiated construct and specifying its relations with other relevant constructs, a good theory is clear about its boundary conditions (Scheel et al., 2021). If researchers fail to observe proposed predictions in these conditions, then the confidence in the underlying model decreases. An important boundary condition of the CHE model (and related stress theories) is that eustress occurs in challenging situations (Kloidt & Barsalou, 2024; Lazarus & Folkman, 1984), in contrast to wellbeing which is typically assumed to occur primarily in non-challenging situations. Any situated assessment of the CHE model therefore needs to identify relevant challenging situations from people's lives where eustress likely occurs. To do so, we developed and tested a diverse set of 20 difficult situations that exhibited different types and levels of challenge, thus were suitable for measuring eustress (Project 3). When implementing the 20 challenging situations in Project 4, we found moderate levels of eustress across our sample, supporting propositions that eustress occurs in challenging situations.

We note, however, that the construct of a challenging situation itself seems less differentiated from threatening situations than proposed by both the transactional model of stress (Lazarus & Folkman, 1984) and the biopsychosocial model of challenges and threats (Blascovich et al., 2000). As our results indicate, threat and challenge both primarily appear to refer to difficult situations and may secondarily differ in their potential for loss versus gain to the individual (and also perhaps the presence of negative versus positive affect), highlighting the importance of transactional processes in addition to a situation's structural properties. These findings align with the classic theoretical perspective of interactionism (Endler & Magnusson, 1974; Fleeson, 2004; Mischel & Shoda, 1995) and with basic definitions of stress as an individual's negative or positive response to any type of difficult situation (Selye, 1936, 1974).

6.3.2 Applied implications

In addition to its theoretical contributions, our research on individual and situational influences of eustress may support interventions that optimize positive stress when desirable and applicable (Crum et al., 2020; Jamieson et al., 2018). Specifically, our research

may inform stress interventions that aim to optimize stress through restructuring the environment and secondary interventions that aim to optimize positive stress by providing individuals with information and skills to pivot from distress to eustress in a difficult situation (Cooper & Cartwright, 1997).

Redesigning stressful environments

Decades of research suggest that stress responses emerge from difficult situations (McEwen, 1998; O'Connor et al., 2021; Schneiderman et al., 2005) that can be further characterized as containing threats that induce distress and challenges that induce eustress (Lazarus & Folkman, 1984). Thus, to effectively foster eustress in individuals, it is important to target challenging situations in their lives, supporting increasingly effective behavior in them. Similarly, an intervention that restructures difficult situations to be challenging instead of threatening may help optimize stress.

In Project 3, we developed and normed a diverse set of 20 challenging situations that may provide promising contexts for developing a eustress intervention in the UK population (for whom these situations were developed and normed). Our results from Project 3 also provide insights into how threatening environments may differ from challenging environments in their overall value related to loss and gain. It follows that decreasing a situation's potential for loss or damage and increasing its potential for gain or rewards may offer a mechanism for redesigning potentially stressful environments. Environmental restructuring to decrease threats and increase challenges can be introduced on the system-level, for instance by companies or schools, or it can be performed on the individual level (referred to as *job crafting*, Sonnentag et al., 2023). Ultimately, these restructuring initiatives may help individuals pivot from distress to eustress in situations where it may not be possible or beneficial to experience no stress at all.

Mapping eustress skills to (groups of) individuals

In addition to redesigning stressful environments, our research also supports mapping different eustress skillsets to different groups of individuals. Extending previous research, we not only observed large individual differences in eustress, but we also identified different groups of individuals who experience eustress similarly. Our latent eustress profiles could inform eustress interventions that teach eustress skills to particular segments of the population. For example, "eustress achievers" exhibited a high level of eustress for goal-directed action but not for momentary experience. Individuals who belong to this profile could therefore focus on developing skills associated with savoring, mindfulness, and social connectedness to increase their eustress. A promising next step for classifying such segments of larger populations would be to identify individuals' eustress profiles using proxy variables, thereby streamlining the clustering process when time-consuming assessments

are not feasible. In Project 2, we began this process by identifying sociodemographic characteristics (e.g., gender) and individual traits (e.g., openness, wellbeing) that differentiated pairs of eustress profiles (although proxy variables that differentiate all profiles simultaneously remain to be established).

Developing personalized and contextualized interventions

Combining insights from individual and situational influences on eustress could ultimately support the design of personalized and contextualized interventions. Using the SAM^2 approach in Project 4, we collected rich, multilevel data to identify facets of the CHE model that most likely foster eustress in each individual (Dutriaux et al., 2023). If, for instance, someone's individual-level predictive profile indicated that their eustress was most strongly linked to positive affect and fulfilment, then strategies to enhance these facets in challenging situations could be promising. Conversely, the SAM^2 approach could also help identify the challenging situations that show the highest eustress potential for each individual (Dutriaux et al., 2023). Supporting the development of coping and action skills, for instance, may be a highly useful for fostering eustress in challenging situations where the individual has some control over a situation but doesn't know which coping skills to use. Ultimately, a personalized and contextualized eustress intervention for each individual could identify the specific eustress skills most likely to increase their eustress in specific challenging settings (Craig et al., 2018).

6.3.3 Implications for using Artificial Intelligence (AI)

This thesis leveraged AI in various processes of the research cycle. In Projects 2 and 3, we used machine learning to identify meaningful patterns in our data (i.e., individuals with similar eustress profiles, situations with similar feature profiles). Project 3 also used an open-source LLM to systematically generate and evaluate a diverse set of difficult situations. Whereas our findings showcase some opportunities and limitations of AI tools in research, the work presented here can also help develop novel AI applications for eustress detection and management.

For instance, the clusters of participants and situations identified in Projects 2 and 3 may be used to develop a machine learning tool that automatically classifies people as distinct eustress types depending on proxy variables (e.g., demographics) or observable behaviors in challenging situations (e.g., facial expressions) thereby reducing the need for complex self-report assessments (e.g., Awada et al., 2024). Another line of enquiry could use virtual reality to situate individuals in challenging situations, ask them to evaluate their eustress, and measure their physiological responses (e.g., heartrate, skin conductance, respiration, eye-tracking). Immersing individuals in a realistic, yet highly controlled set-

ting could help reduce measurement error, while simultaneously identifying biomarkers associated with eustress. Lastly, our predictive profiles in Project 4 could be used to train a chatbot that facilitates the personalized and contextualized eustress intervention described in 6.3.2 Applied implications. Despite their potential, we note that AI eustress tools pose practical risks (e.g., data protection, user safety), intrinsic challenges (e.g., access to digital tools, digital skills to use them effectively), and potentially adverse outcomes (e.g., a digital tool itself can become a source of distress).

Lastly, and on a more general level, the data collected for our research can be useful for developing and testing AI tools. As synthetically generated content increasingly pollutes all types of online media, the acquisition of high quality human data become increasingly valuable (e.g., Rilla et al., 2025). For instance, effectively training an LLM requires non-synthetic training data (Shumailov et al., 2024). Similarly, LLM output needs to be benchmarked against human output to gauge its quality (Harding et al., 2024).

6.4 Limitations

The work in this thesis exhibits clear limitations that are important to address. The first of these is that the eustress model, CHE, on which we based our research, was developed using an empirical, bottom-up approach (Dubin, 1976; Holton & Lowe, 2007). Whereas the CHE model integrates insights from the diverse eustress literatures, its scientific quality critically depends on whether its 47 features, 13 facets, and three sources cover the construct of eustress adequately. To the extent that previous eustress work is limited or biased, CHE's hierarchical structure and content are likely to reflect these limitations as well. Notably, however, our empirical assessments of the CHE model generally support its structure and content, although we also identified minor inconsistencies that could be adjusted. As eustress research continues to grow and evolve, the relevant structure and content of CHE is likely to evolve as well, requiring regular updating.

A related limitation of our research is that we conceptualized eustress as a cognitive, affective, and behavioral construct, thereby ignoring other potentially relevant influences such as biomarkers, epigenetic processes, and system-level structures. Whereas our research is grounded in the assumption that eustress is shaped by individuals and their contexts (Barsalou, 2008, 2009, 2020), our research (and eustress research in general) could further benefit from cross-disciplinary integration (cf. the Theory of Constructed Emotion; Feldman Barrett, 2016). Because some research questions whether eustress is distinct from stress (e.g., Bienertova-Vasku et al., 2020), it will be essential to identify and integrate physiological underpinnings into basic theories of eustress (e.g., Streamer et al., 2017). Because eustress is dynamically influenced by many interconnected components, it is also essential to integrate system-level influences into this line of research as well (e.g.,

Craig et al., 2018; Sniehotta et al., 2017).

Another limitation of our empirical approach is that our results are correlational and should not be used in isolation to inform causal explanations of eustress (Diener et al., 2022; Grosz et al., 2020; Rohrer, 2018). Our results do not provide insights into the mechanisms by which components of the CHE model affect eustress, nor how eustress affects the components of CHE. Still, our results provide evidence that CHE's sources, facets, and features are likely relevant to our theoretical understanding of eustress. Analogously, our results do not provide insights about causal relations of eustress with distress, wellbeing, and stress mindsets. Because eustress research remains in early stages, experimental testing at this point would likely have been premature and uninformative (Scheel et al., 2021).

Our empirical research is also limited because we only assessed eustress in non-probabilistic UK adult samples. Even though most basic demographics of our samples approximated UK population values, we recruited our participants without information about selection probabilities (Heeringa et al., 2017). Because our measurement models are only partially independent from our sample, our results may not generalize towards our target population or other populations, especially from non-WEIRD countries (i.e., Western, Educated, Industrialized, Rich, and Democratic; Henrich et al., 2010) and collectivist cultures (Hendriks et al., 2019). A related issue is that the 20 challenging situations we identified were tailored to the UK population, and therefore may not be comprehensive or relatable in other contexts. To the extent that different populations experience eustress differently and in different situations, the sample of challenging situations could require significant adjustment.

Another limitation of our research is that we collected participants' subjective estimates of their behavior, potentially reflecting inaccurate and biased responses. In Project 2, participants were asked to judge how much they agree with general statements about eustress. To arrive at their judgments, participants may have relied on intuitive theories and/or the availability heuristic instead of averaging across all their relevant situational experiences (Ajzen, 1977; Gelman & Legare, 2011; Tversky & Kahneman, 1973). In Projects 3 and 4, participants evaluated one challenging situation at a time. Nevertheless, participants may not have experienced all the situations presented to them, even though we tried to generate situations that were common or at least relatable to UK adults. Also, because participants had to simulate their experience of these situations from memory, their judgments may not have been as accurate as if they had been generated while actually being in each situation (something difficult to assess empirically in daily activity). Lastly, participants may have been unable to provide accurate self-reports about their eustress because they lack a detailed understanding of the construct and/or conscious access to relevant thoughts and feelings (Corneille & Gawronski, 2024). For these reasons, we always

provided participants with short descriptions of the measurement variables.

A final limitation of this thesis is that it only focuses on positive aspects of stress. As a result, our research is not value neutral and could be misinterpreted as pathologizing normal human behavior and setting unrealistic expectations about the benefits of stress (Englar-Carlson & Smart, 2014; Van Zyl et al., 2023). Because this thesis does not prescribe that stress is inherently good, we highlight that sections on practical applications are only relevant to individuals and situations for which a positive stress response is desired and applicable. Related to this line of criticism, positive psychological research has been critiqued as a neo-liberalist ideology that attributes optimal functioning and flourishing to the individual and their life choices, thereby ignoring contextual and system-level factors (Van Zyl et al., 2023; Yakushko & Blodgett, 2021). Our findings on situation effects and individual-situation interactions in eustress explicitly reject commentary that blames individuals for not experiencing stress positively. Still, further research is needed to address higher level structural issues that may influence stress responses.

6.5 Future Research Directions

Following the research presented in this thesis, there are multiple avenues for future research ideas. The first of these would be to replicate our findings in different populations using probabilistic samples. Although we demonstrated that results from all projects were reliable, it would be interesting to explore whether these findings replicate cross-culturally in collectivistic cultures in addition to individualistic cultures. Future studies could also focus on populations that typically experience high levels of stress (e.g., healthcare workers) or individuals who deliberately seek out stress to enhance performance (e.g., professional athletes). One current barrier to assessing eustress lies in participants' limited access to relevant experiences. Individuals may find it difficult to identify examples of positive stress without additional guidance. In such cases, qualitative research could prove valuable for exploring barriers to understanding eustress and for examining the conceptual clarity and comprehensiveness of the CHE model proposed in this thesis.

Similarly, future research could also expand the range of difficult situations used to measure eustress, including both atypical situations (e.g., holiday season) and highly threatening situations (e.g., facing eviction). Such work could help further delineate the boundary conditions under which eustress emerges. In parallel, further investigating core features distinguishing challenge from threat could inform the design of environments–such as workplaces and schools–that systematically foster positive stress responses across groups. A key methodological advancement would be to measure eustress in real time using ecological momentary assessment rather than relying solely on retrospective recall of situational experiences. Importantly, however, it may often be difficult to sample many

situations that only occur occasionally with ecological momentary assessment. To sample these situations may require using short descriptions as cues to prompt memory, as we did here (see Dutriaux et al., 2023, for further discussion). Complementary approaches could include the use of virtual reality to immerse participants in controlled yet realistic stress-inducing environments, allowing for the simultaneous collection of self-reported and eustress biomarkers.

The current research also lays the groundwork for experimental studies testing causal mechanisms that underlie eustress and its relationships with distress, wellbeing, and stress mindsets. For example, future experiments could investigate whether mindfulness-based training enhances positive experiences in challenging situations or whether coping skill interventions increase eustress and/or reduce overall stress levels. At a broader theoretical level, it would be valuable to test the causal pathways proposed in the CHE model. For example, do successful goal-directed action and fulfilling momentary experiences predict eustress in the real world? Do eustress states, in turn, foster positive and stable psychological qualities? Similarly, longitudinal and experimental work could examine whether eustress interventions lead to increases in general wellbeing, decreases in distress or stress-related illness, and shifts in stress mindsets toward more adaptive interpretations (e.g., through "rethink stress" interventions; Crum et al., 2023).

Finally, future research could advance the development of personalized and context-specific eustress interventions. Individuals might begin by identifying recurring challenges in their daily lives and then evaluating the negative and positive aspects of these experiences. Depending on their appraisals, individuals could either focus on transforming distress into eustress or on further enhancing existing positive responses. Each challenging situation could also be assessed against the nine influential processes identified in Project 4 to identify possible mechanisms that could facilitate the transformation of stress into eustress. Such understanding could further help individuals gain deeper insight into their cognitive, emotional, and behavioral patterns, and to identify new skills for fostering eustress. For example, feelings of connection might be enhanced through gratitude or prosocial behaviors, whereas coping and action-oriented responses could be strengthened through problem-solving skills.

6.6 Conclusion

This thesis demonstrated how individual and situational influences shape eustress—the positive experience of a challenging situation. Through the lenses of critical realism and grounded cognition, the findings provide evidence that eustress and its underlying influential processes are inherently shaped by individuals, situations, and their interactions. UK adults can experience eustress through different combinations and intensities of successful

goal-directed action, fulfilling momentary experiences, and positive stable qualities. Eustress typically emerges in challenging contexts—difficult situations with limited coping options with the potential for experiencing more gains than losses. Ultimately, eustress (as any other stress response) varies as a function of the individual's experience in a specific challenging situation, highlighting the need for personalized and context-sensitive interventions to optimize stress when desirable and applicable.

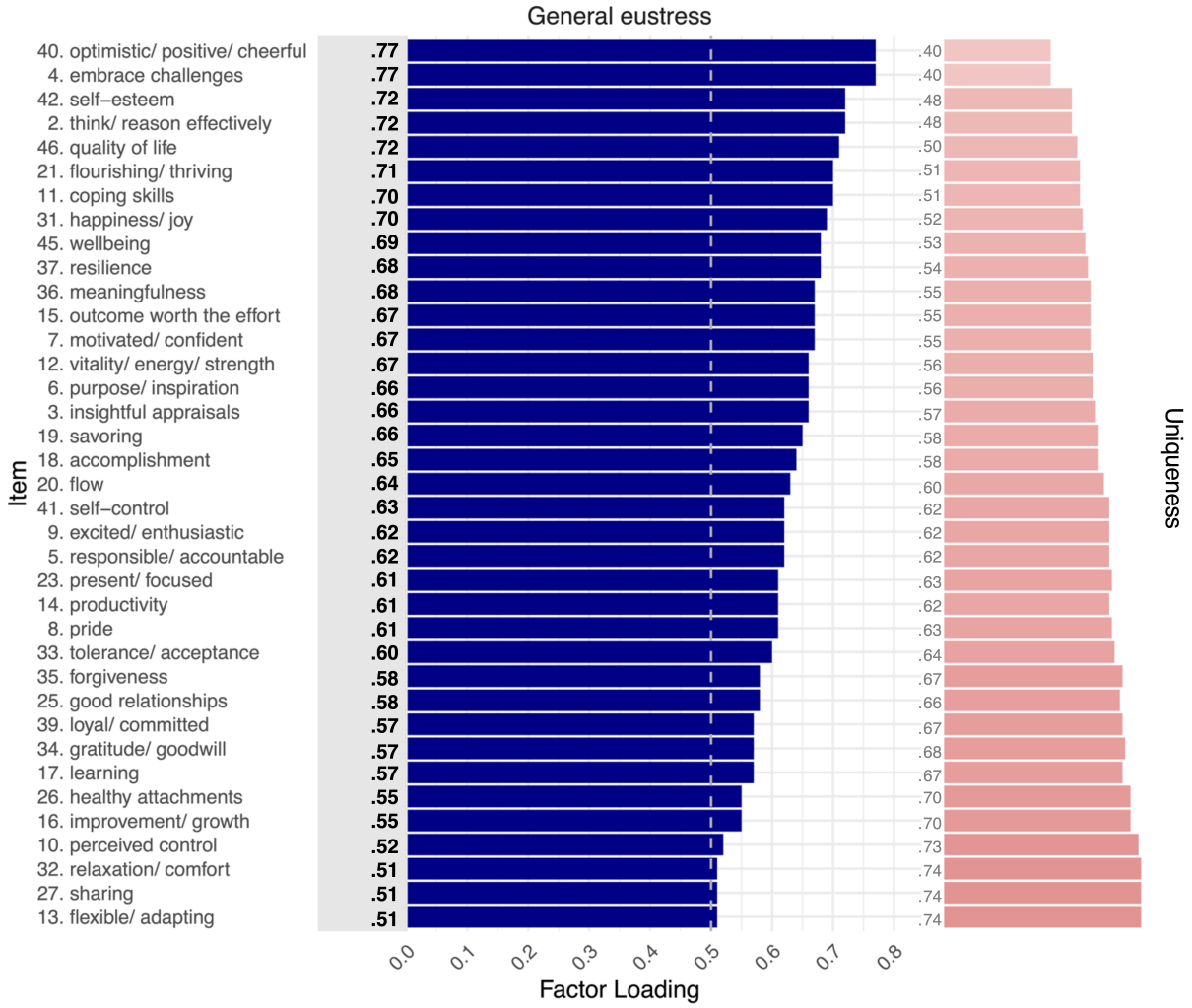
Appendix A

Appendix

A.1 Comprehensive Hierarchical Eustress Review (CHER)

Figure A.1

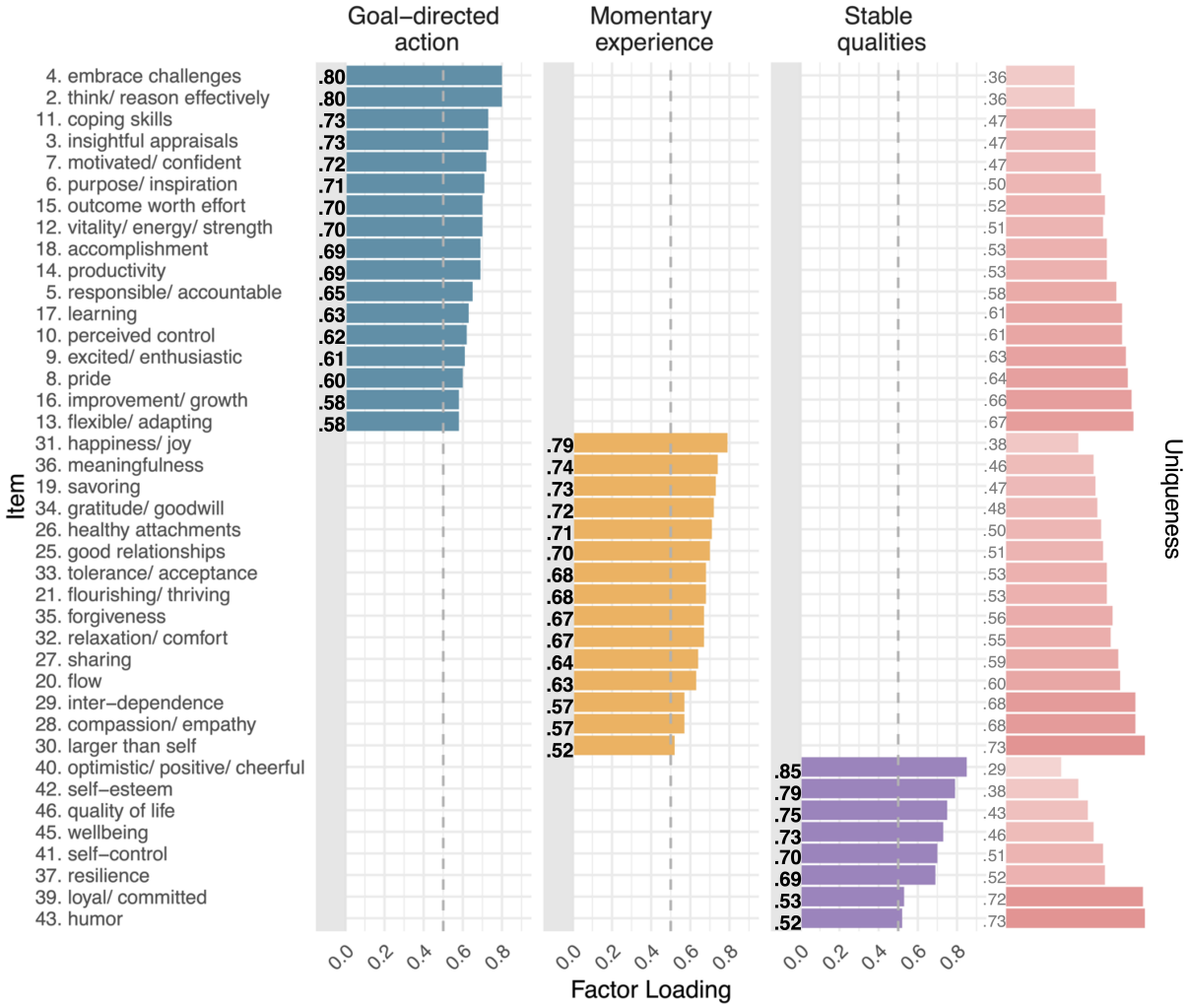
Factor loading plot for Model 1 (unidimensional)



Note. M1 captured 37 (out of 47) CHER items with main factor loadings $\geq .50$ (dashed gray line). M1 accounted for 40.41% of total variance. Factor loadings $\geq .50$ are bolded. Light gray rectangles distinguish negative factor loadings. $N = 260$

Figure A.2

Factor loading plot for Model 2 (correlated factors)



Note. M2 captured 40 (out of 47) CHER items with main factor loadings ≥ .50 (dashed gray line). The correlated factors modelled CHER's subscales of goal-directed action (17 items), momentary experience (15 items), and stable qualities (eight items). M3 accounted for 46.54% of total variance, with most variance explained by goal-directed action (42.48%), followed by momentary experience (36.27%), and stable qualities (21.25%). Factor loadings ≥ .50 are bolded. Light gray rectangles distinguish negative factor loadings. $N = 260$

Table A.1

Latent profile analysis models: Fit statistics and diagnostic criteria

Fit statistics							
K	**LL**	**AIC**	**BIC**	**SABIC**	**AWE**	**CAIC**	**BF**
1	**−1335.23**	2686.45	2714.94	2689.57	**2781.42**	2722.94	0.580
2	−1320.78	2667.56	2713.85	2672.63	2823.72	2726.85	0.003
3	−1301.19	2638.37	2702.46	2645.40	2855.30	2720.46	0.003
4	−1281.50	2609.00	**2690.90**	2617.98	2886.33	**2713.90**	**10.376**
5	−1269.94	**2595.88**	2695.58	**2606.81**	2933.74	2723.58	**>10M**
6	−1272.21	2610.41	2727.92	2623.29	3008.95	2760.92	–

Diagnostic criteria						
K	**Smallest class count (*n*)**	**Smallest class size (%)**	**Entropy**	**min. ALCPP**	**BLRT *p***	**VLMR-LRT *p***
1	260	**100**	–	–	–	–
2	29	**11.2**	**0.709**	**0.606**	**<.01**	**<.001**
3	51	**19.6**	0.630	**0.748**	**<.01**	**<.001**
4	22	**8.46**	**0.732**	**0.684**	**<.01**	**<.001**
5	2	0.77	**0.770**	**0.722**	**<.01**	**<.001**
6	14	**5.38**	**0.736**	0.547	0.455	1.000

Note. Bolded values indicate satisfactory fit for each respective statistic. The 5-cluster solution had convergence issues and was therefore dismissed for model selection. We chose the four-cluster solution as best-fitting model. K = number of clusters; LL = log-likelihood; AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-size adjusted BIC; AWE = approximate weight of evidence criterion; CAIC = consistent AIC; BF = Bayes factor; min. ALCPP = minimum of the average latent class posterior probability; BLRT = bootstrapped likelihood ratio test; p = p-value; VLMR-LRT = Vuong-Lo-Mendell-Rubin adjusted likelihood ratio test. $N = 260$

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