Institut für Erziehungswissenschaft, Universität Bern

# The Cognitive Associations Between Subjective Vitality, Motivation to Conserve Energy, and Motivation for Cognitive Effort

Inauguraldissertation der Philosophisch-humanwissenschaftlichen Fakultät

der Universität Bern zur Erlangung der Doktorwürde

vorgelegt von

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aus Luxemburg

Bern & Köniz | Mai 2024

Von der Philosophisch-humanwissenschaftlichen Fakultät der Universität Bern auf Antrag von

Prof. Dr. Alex Bertrams und Prof. Dr. Chris Englert angenommen.

Bern, den 27. Mai 2024 Der Dekan: Prof. Dr. Elmar Anhalt

# A Brief Overview and Explanatory Remarks on the Three Studies Conducted Within the Present Cumulative Work

## When Self-Control Fails

In an ideal world, where self-control reigns supreme, beach bodies would effortlessly materialize, smokers would quit on the first attempt, fidelity would be unwavering, no sweet temptation would be too hard to resist, and society would shine bright in new splendor. However, reality proves otherwise. Despite our best efforts, self-control occasionally fails. This is especially true following periods of intense self-regulation, resulting in a temporary state of reduced self-control strength—a phenomenon commonly referred to as ego depletion (Englert, 2021).

## Current Models Explaining Ego-Depletion Effects and Their Shortcomings

Over the past two decades, numerous scholars have devoted their research to the causes and mechanisms of self-control failure. One of the earliest works was the *strength model of self-control* (Baumeister et al., 1998; Baumeister et al., 2007), suggesting that activities requiring self-control, such as overriding predominant responses, may deplete individuals' self-control resources and result in impaired performance in subsequent self-control tasks. Later, Baumeister and Vohs (2016) revisited their strength model, offering further clarifications on the nature of this finite resource by positing the presence of a central governor within the brain, responsible for monitoring and allocating energy usage strategically. In contrast, Inzlicht et al. (2012) consider more mechanistic accounts as to why self-control seems limited. In their *process model of ego depletion,* the authors propose that exerting self-control in an initial task triggers a shift in motivation and attention, making mentally demanding work such as exerting self-control less appealing and leisure activities more attractive. Kurzban et al. (2013) posit in their *opportunity cost model* that the anticipated costs and benefits of tasks influence subjective experiences such as frustration or flow, which in turn guide the allocation of self-control towards tasks expected to yield optimal outcomes.

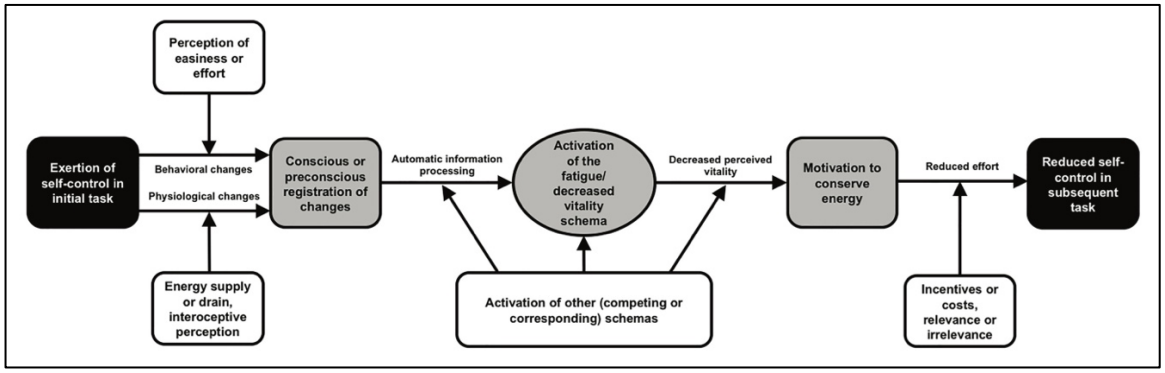
However, each of these models has its specific limitations, failing to adequately explain certain aspects of the mechanics behind ego-depletion or the nature of the limited resource in a robust manner (Bertrams, 2020). What unites those approaches in their shortcomings is that none of them can explain two phenomena: the vicarious depletion effect, where individuals feel depleted when adopting the perspective of someone else engaged in self-control, and the imaginary depletion effect, where individuals feel

depleted after merely imagining exerting self-control (Betrams, 2020). Although no actual self-control is performed and consequently no tangible "self-control resources" are consumed, the mere occurrence of these specific ego-depletion effects (e.g., Englert & Bertrams, 2014; Graham et al., 2014) suggest the activation of some sort of depletion schema, potentially causing the decline in cognitive performance. Hence, Bertrams (2020) introduces a novel *schema model of self-control*, incorporating a fatigue or decreased vitality schema into the causal chain to comprehensively explain self-control failure and address the limitations of prior models.

## The Schema Model of Self-Control

**Figure 1**

*The Schema Model of Self-Control*




*Note.* Taken from Bertrams, 2020. Black boxes: observable behavior in self-control studies. Gray boxes and horizontal arrows: mediating processes within the individual. White boxes: moderating variables.

The schema model (Bertrams, 2020), at its core, posits the activation of a fatigue/decreased vitality schema as the central driver behind the ego-depletion effect. In fact, when individuals engage in effortful self-control during an initial task, they may consciously or preconsciously notice behavioral and physiological changes. On a behavioral level, individuals may become aware of these observed changes as they transition from executing routine tasks effortlessly to engaging in deliberate self-regulation. Likewise, on a physiological level, fluctuations in heart and brain activity may be registered by individuals after exerting self-control. Upon recognition of these changes, a schema associated with reduced vitality or increased fatigue is activated, leading to a perceived decline in energy levels (i.e., subjective vitality) available for intentional self-regulation. Consequently, individuals are motivated to conserve their remaining energy resources, resulting in a reduction in cognitive effort expenditure (i.e., self-regulation) to preserve resources. This adaptive response ultimately leads to diminished performance in subsequent self-control tasks. The model also posits that various moderators can influence these mechanisms at different

stages, potentially strengthening or weakening their effects. Thus, the schema model integrates the complex interplay between cognitive, physiological, and motivational factors in self-regulation.

**From Mental Associations to Behavior: Empirical Evidence for the Schema Model**

According to Bertrams (2020, p.2), "for schema activation, even the mental concept of self-control effort has to be causally related to decreased vitality", so that actual self-control behavior can be translated into the assumed information-processing mechanism. To date, Bertrams (2021) has empirically investigated this premise by showing that effortful self-control behavior is mentally associated with fatigue or decreased vitality (see left half of Fig. 1). A key aspect that remains to be tested is the mental association between decreased subjective vitality (indicating the activation of the fatigue/decreased vitality schema), the motivation to conserve energy, and the related motivation to reduce cognitive effort (see right half of Fig. 1). The existence of a mental association between these three variables appears essential for individuals to translate their beliefs into actionable behaviors. More precisely, individuals who possess a mental concept, wherein decreased subjective vitality signals the organism to conserve energy, are inclined to adjust their behavior accordingly. Consequently, they may decrease their cognitive efforts (i.e., self-regulation) when feeling depleted in order to conserve their remaining energy resources. Empirically, there is convincing evidence that people behave according to their beliefs (Gainsburg & Lee Cunningham, 2023; Job et al., 2010) which further supports the idea of analyzing the schema model on the level of mental associations first.

**The Present Cumulative Work**

Given the identified gaps mentioned above, the objective of this cumulative work is to explore the mental representations individuals hold regarding the associations between subjective vitality, the motivation to conserve energy, and subsequent willingness to invest cognitive effort. Although validated self-reports to assess subjective vitality are available in German (e.g., Bertrams et al., 2020; Goldbeck et al., 2019), there are currently neither scales available to assess individuals' motivation to conserve energy nor to measure their momentary motivation for cognitive effort. Hence, to effectively investigate the main objective in a valid and reliable manner (Study 3), we first had to craft the necessary tools ourselves, a self-report scale to assess momentary motivation for cognitive effort (Study 1) and one to assess motivation to conserve energy (Study 2).

**Paper 1: Measuring Motivation for Cognitive Effort as State**

The objective of this research was to develop and validate a scale to measure individuals' momentary motivation for cognitive effort—the Motivation for Cognition scale (MFC). Rather than developing a wholly novel measure, we chose to adapt an established trait measure of cognitive motivation, the German Need for Cognition Scale (NFC; Bless et al., 1994). We adjusted both the instruction and the 34 items of the NFC scale to align with a state-focused approach. This included for example replacing terms like "in general" with "right now". Next, three reviewers selected ten items based on considerations of language and content validity. In the final questionnaire, each of the items (e.g., "Currently, I prefer complex problems over simple ones") is answered on a seven-point Likert scale ranging from –3 (*does not apply at all*) to +3 (*applies exactly*).

Following the development phase, we conducted two studies to assess the MFC scale's factorial structure and psychometric properties. Given that the scale was entirely new, exploratory factor analysis was employed, indicating a single-factor solution. More importantly, the primary validation of the MFC scale was conducted through a task difficulty choice paradigm, in which participants indicated their preferred difficulty level (ranging from 1 "easy" to 6 "very difficult") for a forthcoming task. The idea of using this approach was based on the findings that individuals with high NFC levels tend to prefer tasks of greater difficulty across various situations (Bertrams & Dickhäuser, 2010; Kramer et al., 2021). Given our assumption that administering the MFC state-scale in close temporal proximity to task-choice behavior would yield more robust results compared to the temporally distant NFC trait-scale, we hypothesized that the MFC scale would positively predict participants' willingness to invest cognitive effort in a subsequent task over and above NFC, even after controlling for other relevant trait[1] and state[2] variables.

Consistent with our hypothesis, the results revealed that the MFC scale was superior to all validation criteria in predicting task difficulty choices as it significantly predicted state motivation for cognitive effort over and beyond the applied state and trait measures. Overall, the findings suggest that the MFC scale is a psychometrically sound measure. It captures a unidimensional construct with strong internal consistency. Moreover, the scale shows meaningful associations with state and trait constructs from the nomological net of effort motivation and outperforms these measures in predicting state motivation for cognition.

[1] Trait-measures: hope for success and fear of failure (Lang & Fries, 2006)
[2] State-measures: self-control capacity (Bertrams et al., 2011), subjective vitality (Bertrams et al., 2020), positive affect and negative affect (Krohne et al., 1996)

**Paper 2: My Precious: Development and Validation of the Conservation of Human Energy Resources Index (CHERI)**

The aim of the present research was to develop and validate a brief scale to assess individuals' motivation to conserve their energy resources. During the item development phase, we drew upon the terminology associated with constructs within the nomological net of human energy, such as physical energy (Quinn et al., 2012), energetic activation (Weigelt et al., 2022), and subjective vitality (Ryan & Frederick, 1997). In the end, a five-item state scale[3] emerged, the Conservation of Human Energy Resources Index (CHERI), available in both German (CHERI-G) and English (CHERI-E) versions. The instruction of the CHERI-E reads "How are you feeling at the moment?" and items (e.g., "Right now, I want to use as little of my energy as possible") are rated on a scale ranging from 1 (*not at all true*) to 6 (*completely true*).

Afterwards, in four studies, we examined the CHERI's psychometric properties. In Study 1, an exploratory factor analysis with data from a student sample suggested a one-factor solution of the CHERI-G, which was further confirmed by confirmatory factor analysis in Study 2. Moreover, the CHERI-G exhibited significant associations with various effort-related measures[4] from the academic context. In Study 3, a pre-registered investigation, we assessed teachers' motivation to conserve energy before and after teaching. The results underscored the CHERI-G's sensitivity to change, affirming its underlying state nature. Additionally, we provided support for criterion validity by demonstrating that mental effort during teaching positively predicted energy conservation motivation after teaching. In Study 4, which was also pre-registered, we developed an English version of the scale "CHERI-E" and validated it by demonstrating its associations with work-related validation criteria[5] in a sample of individuals from various occupations. Furthermore, since measurement invariance was confirmed across both cultural (German vs. English) and social (workplace vs. academia) contexts, we conclude that the CHERI is suitable for use in various settings and populations without significant information loss.

[3] Originally the CHERI-G was designed with six items, yet the CFA in Study 2 showed that the model produced a significantly better model fit when the redundant item number six was omitted.
[4] The validation criteria were MFC (Blaise et al., 2021), subjective vitality (Bertrams et al., 2020), achievement motivation (Lang & Fries, 2006), implicit theories of willpower (Job et al., 2010), and energetic activation (Weigelt et al., 2022).
[5] The validation criteria were need for recovery (van Veldhoven & Broersen, 2003), energy management strategies (Fritz et al., 2011), emotional exhaustion (Maslach & Jackson, 1981), proactive vitality management (Op den Kamp et al., 2018), and vigor (Schaufeli et al. , 2006).

**Paper 3: The Mental Association Between Subjective Vitality, Energy Conservation Motivation, and Cognitive Effort Motivation According to the Schema Model of Self-Control**

This research aimed to investigate the overarching goal of the present cumulative work: examining individuals' mental associations between subjective vitality, motivation to conserve energy, and cognitive effort motivation within the framework of schema model theory (Bertrams, 2020). With the development and validation of the required scales—the CHERI for assessing motivation to conserve energy and the MFC scale for assessing motivation for cognitive effort—we were now prepared to rigorously test our main hypotheses. We expected participants to hold a mental representation wherein low vitality, compared to high vitality, is linked to increased motivation to conserve energy and decreased cognitive motivation.

To test our hypotheses, participants were presented with either prefilled vitality questionnaires of fictitious characters (Study 1) or short descriptions of office workers (Study 2), with vitality levels being experimentally manipulated. Participants then rated the characters' motivation to conserve energy and motivation for cognitive effort. Across both studies, the results consistently supported our hypotheses. Participants associated characters expressing low vitality with a higher need to conserve energy and lower motivation for cognitive effort compared to those expressing high vitality. In line with the predictions of the schema model, mediation analysis revealed that the mental association between subjective vitality and the motivation for cognitive effort is partially mediated by a motivation to conserve energy. This finding suggests that individuals perceive it beneficial to conserve their energy during periods of low vitality, leading to decreased motivation for cognitive efforts, as exertion can be viewed as detrimental to maintaining personal energy levels. Implications for psychological research and practice are discussed.

**Conclusion**

In summary, this cumulative work significantly contributes to the field of ego-depletion research by providing empirical support for previously untested theoretical assumptions outlined in Bertrams' (2020) schema model of self-control. Through meticulous development and validation of custom measurement instruments aimed at assessing the core variables of the schema model, our findings strongly illustrate the cognitive associations individuals have regarding the interplay of these variables. This groundwork is essential for probing the schema model's postulated mechanisms and exploring their implications in real-world behavior.

**References**


Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*, 1252–1265. https://doi.org/10.1037/0022-3514.74.5.1252

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current directions in psychological science*, *16*, 351–355. https://doi.org/10.1111/j.1467-8721.2007.0053

Bertrams, A. (2020). A schema-activation approach to failure and success in self-control. *Frontiers in Psychology*, *11*, 2256. https://doi.org/10.3389/fpsyg.2020.02256

Bertrams, A. (2021). The cognitive association between effortful self-control and decreased vitality. *Frontiers in Psychology*, *12*, 631914. https://doi.org/10.3389/fpsyg.2021.631914

Bertrams, A., & Dickhäuser, O. (2010). University and school students' motivation for effortful thinking: factor structure, reliability, and validity of the German need for cognition scale. *European Journal of Psychological Assessement*, *26*, 263–268. https://doi.org/10.1027/1015-5759/a000035

Bertrams, A., Dyllick, T. H., Englert, C., & Krispenz, A. (2020). German adaptation of the subjective vitality scales (SVS-G). *Open Psychology*, *2*, 57–75. https://doi.org/10.1515/psych-2020-0005

Bertrams, A., Unger, A., & Dickhäuser, O. (2011). Momentan verfügbare Selbstkontrollkraft– Vorstellung eines Messinstruments und erste Befunde aus pädagogisch-psychologischen Kontexten [Momentarily available self-control strength—Introduction of a measure and first findings from educational psychological contexts]. *Zeitschrift für Pädagogische Psychologie. [German Journal of Educational Psychology], 25,* 185–196. https://doi.org/10.1024/1010-0652/a000042

Blaise, M., Marksteiner, T., Krispenz, A., & Bertrams, A. (2021). Measuring motivation for cognitive effort as state. *Frontiers in Psychology, 12*, 785094. https://doi.org/10.3389/fpsyg.2021.785094

Bless, H., Bohner, G., Fellhauer, R. F., and Schwarz, N. (1994). Need for Cognition: Eine Skala zur Erfassung von Engagement und Freude bei Denkaufgaben [Need for cognition: a scale measuring engagement and happiness in cognitive tasks]. *Zeitschrift für Sozialpsychologie [German Journal of Social Psychology], 25*, 147–154.

De Bloom, J., Kinnunen, U., & Korpela, K. (2015). Recovery processes during and after work. *Journal of Occupational and Environmental Medicine*, *57*, 732–742. https://doi.org/10.1097/JOM.0000000000000475

Englert, C. (2021). The strength model of self-control. In *Motivation and Self-Regulation in Sport and Exercise* (pp. 102–112). Routledge.

Englert, C., & Bertrams, A. (2014). What is self-control depleting in sports? Effects of vicarious experiences on performance. *International Journal of Sport Psychology, 45*, 1–10. https://doi.org/10.1017/cbo9780511779008.002

Fritz, C., Lam, C. F., & Spreitzer, G. M. (2011). It's the little things that matter: An examination of knowledge workers' energy management. *The Academy of Management Perspectives*, *25*, 28–39. https://doi.org/10. 5465/amp.25.3.zol28

Gainsburg, I., & Lee Cunningham, J. (2023). Compassion fatigue as a self-fulfilling prophecy: Believing compassion is limited increases fatigue and decreases compassion. *Psychological Science*, *34*, 1206–1219. https://doi.org/10.1177/0956797623119453

Goldbeck, F., Hautzinger, M., & Wolkenstein, L. (2019). Validation of the German version of the subjective vitality scale-a cross-sectional study and a randomized controlled trial. *Journal of Well-Being Assessment*, *3*, 17–37. https://doi.org/10.1007/s41543-019-00019-8

Graham, J. D., Sonne, M. W., & Bray, S. R. (2014). It wears me out just imagining it! Mental imagery leads to muscle fatigue and diminished performance of isometric exercise. *Biological Psychology*, *103*, 1–6. https://doi.org/10.1016/j.biopsycho.2014.07.018

Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives on Psychological Science*, *7*, 450–463. https://doi.org/10.1177/1745691612454134

Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion – Is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*, 1686–1693. https://doi.org/10.1177/0956797610384745

Kramer, A. W., Van Duijvenvoorde, A. C., Krabbendam, L., & Huizenga, H. M. (2021). Individual differences in adolescents' willingness to invest cognitive effort: Relation to need for cognition, motivation and cognitive capacity. *Cognitive Development*, *57*, 100978. https://doi.org/10.1016/j.cogdev.2020.100978

Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Untersuchungen mit einer deutschen Version der "Positive and Negative Affect Schedule" (PANAS) [Investigations with a German

version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica, 42, 139–156.* https://doi.org/10.1037/t49650-000

Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences*, *36*, 661–679. https://doi.org/10.1017/S0140525X1200319

Lang, J. W. B., & Fries, S. (2006). A revised 10-item version of the achievement motives scale: psychometric properties in German-speaking samples. *European Journal of Psychological Assessment, 22,* 216–224. https://doi.org/10.1027/1015-5759.22.3.216

Maslach, C., & Jackson, S. E. (1981). The measurement of experienced burnout. *Journal of Organizational Behavior*, *2*, 99–113.https://doi.org/10.1002/job.4030020205

Op den Kamp, E. M., Tims, M., Bakker, A. B., & Demerouti, E. (2018). Proactive vitality management in the work context: Development and validation of a new instrument. *European Journal of Work & Organizational Psychology*, *27*(4), 493–505. https://doi.org/10.1080/1359432X.2018. 1483915

Quinn, R. W., Spreitzer, G. M., & Lam, C. F. (2012). Building a sustainable model of human energy in organizations: Exploring the critical role of resources. *Academy of Management Annals*, *6*, 337–396. https://doi.org/10.5465/19416520.2012.676762

Ryan, R. M., & Frederick, C. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*(3), 529–565. https://doi.org/10.1111/j.1467-6494.1997. tb00326.x

Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and Psychological Measurement, 66*, 701–716. https://doi.org/10.1177/0013164405282471

Van Veldhoven, M. J. P. M., & Broersen, S. (2003). Measurement quality and validity of the “need for recovery scale”. *Occupational and Environmental Medicine, 60*, i3-i9. http://dx.doi.org/10.1136/oem.60.suppl_1.i3

Weigelt, O., Gierer, P., Prem, R., Fellmann, M., Lambusch, F., Siestrup, K., Marcus, B., Franke, T., Tsantidis, S., Golla, M., Wyss, C., & Blume, J. (2022). Time to recharge batteries–development and validation of a pictorial scale of human energy. *European Journal of Work and Organizational Psychology*, *31*, 781–798. https://doi.org/10.1080/1359432X.2022.2050218

frontiers in Psychology

ORIGINAL RESEARCH
published: 09 December 2021
doi: 10.3389/fpsyg.2021.785094

# Measuring Motivation for Cognitive Effort as State

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People's motivation to engage in cognitive effort is a variable which is relevant in different psychological domains (e.g., social cognition research). Despite its potential benefits, a psychometrically sound state measure of cognitive motivation is still lacking. We therefore developed the 10-item motivation for cognition (MFC) state scale based on the established conceptualization and measure of trait need for cognition (NFC). In two studies, we examined the psychometric properties of the new measure. Study 1 revealed that the MFC scale reliably measures a one-dimensional construct. Moreover, the MFC scale was related to NFC and choice of task effort in an expected manner. In Study 2, relationships with NFC, achievement motives, self-control capacity, subjective vitality, momentary affect, and choice of task effort provide further preliminary support for the MFC scale as being a valid measure of momentary cognitive motivation. We discuss the utility of the new scale in psychological research and practice.

**Keywords: cognitive motivation, effort, need for cognition, psychometrical scale, measurement**

OPEN ACCESS

***Edited by:***
*Monika Fleischhauer,*
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***Specialty section:***
*This article was submitted to Personality and Social Psychology, a section of the journal Frontiers in Psychology*

***Received:*** *05 October 2021*
***Accepted:*** *18 November 2021*
***Published:*** *09 December 2021*

***Citation:***
*Blaise M, Marksteiner T, Krispenz A and Bertrams A (2021) Measuring Motivation for Cognitive Effort as State. Front. Psychol. 12:785094. doi: 10.3389/fpsyg.2021.785094*

## INTRODUCTION

In modern times people must process complex information almost daily. Individuals are required, for example, to resolve mental tasks assigned at work or in academic contexts, to make decisions based on sellers' or politicians' claims, or to organize their and their families' prosperity. As various dual-process theories propose (see Evans, 2008), information can be encountered and processed in roughly two ways—either effortlessly (automatic, reflexive, heuristic) or effortfully (controlled, reflective, analytic). How much cognitive effort people tend to invest in processing information has crucial implications for what they achieve, the decisions they make, how they actively search for information in social settings, and even how well they are emotionally adjusted (Preckel et al., 2006; Bertrams and Dickhäuser, 2009, 2012; Fleischhauer et al., 2010; Carnevale et al., 2011; Curşeu, 2011; Harman, 2011; Meier et al., 2014). Consistently, individual differences in the motivation to expend cognitive effort have been a subject of rigorous psychological research (for a review, see Cacioppo et al., 1996). The present work deals with the measurement of such cognitive motivation. Specifically, we aim at supplementing the existing measures of respective individual differences with a state measure that is still lacking.

Research has frequently shown that the extent to which people apply cognitive effort in a given situation depends on various factors. For instance, when distracted, or when their self-regulatory resources are depleted, people are unlikely to spend cognitive resources on in-depth processing of current information; they rather tend to use ways of information processing that require low effort, such as applying heuristics and stereotypes (e.g., Newman, 1996; Dudley and Harris, 2003; Pohl et al., 2013). Motivation is another crucial determinant of how intensely individuals engage in effortful cognitive processes. In various psychological realms, including educational psychology

(e.g., Preckel et al., 2006; Bertrams and Dickhäuser, 2009; Meier et al., 2014), consumer psychology (e.g., Zhang, 1996; Drolet et al., 2009), and social cognition (e.g., Dudley and Harris, 2003; Tormala and Clarkson, 2008), motivation for cognitive effort has often been examined by relying on individual differences in need for cognition (NFC).

Need for cognition refers to stable individual differences in people's tendency to engage in and enjoy effortful cognitive activity (Cacioppo and Petty, 1982). Across situations, people high in NFC are motivated to invest cognitive effort; for example, when considering arguments (Cacioppo et al., 1986), when choosing from tasks of different cognitive difficulty (Bertrams and Dickhäuser, 2010; Kramer et al., 2021), and when completing cognitively challenging tasks (Unnikrishnan Nair and Ramnarayan, 2000; Rudolph et al., 2018). Cacioppo et al. (1996) extensive review of the literature revealed that people high in NFC actually spend more cognitive effort in an array of cognitive challenges. In contrast, people low in NFC display a relative absence of engagement in and enjoyment of cognitive effort (Cacioppo et al., 1996). In terms of teaching and learning, several findings of the recent years contribute to a better understanding of NFC and its role in the classroom. For instance, students low in NFC are more likely to experience math anxiety, which in return, is related to poorer math performance (Maloney and Retanal, 2020). When it comes to reading and memorizing, learners high in NFC rely on elaborate learning strategies even in the absence of explicit instruction, whereas individuals low in NFC benefit more from these strategies than their peers high in NFC (Schindler et al., 2019). Recently, numerous other variables in student populations have been of particular interest in NFC research, e.g., in student teachers (Grass et al., 2018) or in third to ninth graders (Luong et al., 2017); underlining its relevance for educational psychology as well.

In order to tap NFC, the NFC scale (embedding a brief version) has been developed and found to have good psychometric properties (Cacioppo and Petty, 1982; Bless et al., 1994; Cacioppo et al., 1996; German adaptation: Bertrams and Dickhäuser, 2010; Preckel, 2014). The NFC scale assesses individuals' general tendency to be motivated to engage in cognitive effort across various situations; that is, NFC is conceptualized and measured as a relatively stable individual difference (Cacioppo et al., 1996). However, we are not aware of an existing state measure of NFC. Such a state measure would be a useful tool, as indicated by research on affect and emotion where the trait–state distinction in variables and their measures is well-established. Prominent examples are the Positive and Negative Affect Schedule (Watson et al., 1988), the State-Trait Anxiety Inventory (Spielberger et al., 1970), and the Subjective Vitality Scales (Ryan and Frederick, 1997). Traits may be considered as dispositions which are there all along but only manifest from time to time in reaction to relevant situations, whereas states may be seen as concrete occurrences (Fridhandler, 1986; Spielberger and Vagg, 1995). According to Fridhandler (1986), the concepts of state and trait basically differ on the dimensions of (a) short vs. long duration, (b) continuousness vs. reactivity, (c) concreteness vs. abstractness, and (d) situational vs. personal causality. Thus, the trait–state distinction is important for accurate measurement, depending on whether dispositions or actual momentary experiences in specific situations are the focus of interest. We propose that this may apply to motivation for cognitive effort, too.

Though NFC, measured as a trait, has been found to predict behavior in concrete situations (see Cacioppo et al., 1996), a respective state measure, completed in temporal proximity to the assessment of the interesting criterions, may even more reliably disclose expected relationships. Consistently, we assume that researchers and practitioners would benefit from a reliable and valid state measure of motivation for cognitive effort. For example, Fleischhauer et al. (2015) argue that their repeated measurements of participants' NFC self-concept might have induced NFC state effects. In this case, it could make sense to control for any unintended side effects by applying a NFC-related state measure.

We therefore developed a state measure of motivation for cognitive effort based on the German version (Bless et al., 1994) of Cacioppo and Petty (1982) NFC (trait) scale. The German NFC scale has been found to be a reliable and valid measure (Bless et al., 1994; Bertrams and Dickhäuser, 2010), and was hence a suitable basis for this endeavor. In addition to displaying good psychometric properties, we intended the new scale to consist of no more than 10 items. The reason for this was that we expect a state measure of cognitive motivation to be primarily applied in experiments or else in the field, where time for data collection is usually scarce. Recent research has shown the psychometric usability of even much shorter self-report measures (Gogol et al., 2014).

For developing a 10-item state scale, we first adapted the instruction and items of the German NFC scale (Bless et al., 1994) for assessing a momentary motivational state. Then, we selected 10 items based on content- and language-related grounds.

Afterwards, in Study 1, we examined the new state scale's factorial structure and psychometric properties (inner consistency, validity). The conceptually closely related NFC scale has usually been considered as one-factorial (e.g., Cacioppo and Petty, 1982; Bertrams and Dickhäuser, 2010), but diverging structures also have been received and discussed (Tanaka et al., 1988; Davis et al., 1993). For this reason, and because the state scale was a completely new measure, we preferred exploratory over confirmatory factor analysis. Moreover, for initial validation purposes, we examined the relation between the new state scale and the NFC scale. We expected both measures to be strongly positively related because they refer to the same construct (i.e., cognitive motivation). Furthermore, we hypothesized that the new state scale would be positively related to the cognitive effort one would momentarily be willing to invest in a cognitive task. Since deciding whether to engage in a challenging task highlights the volitional aspects inherent in the concept of effort, task-choice procedures indicate the willingness to exert cognitive effort (Westbrook and Braver, 2015). Findings from studies on cognitive effort discounting showed that people avoid cognitively demanding tasks based on subjective cost calculations (e.g., Westbrook et al., 2013). It seems that individuals high in NFC are less likely to avoid, respectively, are more motivated to engage in cognitively demanding activities than people low in NFC. As

our new state measure can be understood as a more proximal measure of cognitive motivation, we predicted that responses obtained from the new state scale are related to task choice over and above trait NFC.

In Study 2, we aimed to further investigate the validity of the new state measure. For this purpose, we tested whether the state scale is theoretically meaningfully related to several trait and state measures. As in Study 1, we assessed NFC and expected the state scale responses to be positively related to NFC. In addition, we applied a measure of dispositional achievement motives, specifically, *hope of success* and *fear of failure*. Hope of success is an approach tendency and fear of failure an avoidance tendency with respect to achievement situations (Clark et al., 1956; Lang and Fries, 2006). As achievement often requires cognitive effort, people higher compared to lower in hope of success may more likely feel motivated to engage in cognitive effort, expressing their propensity to approach achievement situations. The contrary may apply with regard to fear of failure and the expression of avoidance of achievement situations. Thus, we assumed higher state scale responses to be associated with higher hope of success and lower fear of failure, respectively. Whether people engage in effortful cognition or rely on effortless heuristics has been shown to depend on their current *self-control capacity* (Masicampo and Baumeister, 2008; Pocheptsova et al., 2009; Pohl et al., 2013). Moreover, cognitive motivation has been found to decrease with lowered self-control capacity (Finkel et al., 2006). Based on these previous findings, we predicted the new state scale measure and state self-control capacity to be positively related. The state scale should be positively related to current *subjective vitality* as well. Subjective vitality is typically associated with high intrinsic motivation (Kasser and Ryan, 1996; Ryan and Frederick, 1997). As NFC is considered a kind of intrinsic motivation (Cacioppo et al., 1996), so should its state counterpart. Based on similar grounds—that is, the established relation between intrinsic motivation and *positive affect* (e.g., Gillet et al., 2013)—we also expected people with higher responses to the new state scale to experience higher momentary positive affect. As suggested by recent research (Gillet et al., 2013), state cognitive motivation as an intrinsic motivation may be merely weakly negatively related to momentary *negative affect*. Furthermore, as in Study 1, we examined whether higher values on the new state scale predict choice of cognitively more demanding task options. Both the state scale as well as the task choice are considered to be proximal state measures of cognitive motivation and, thus, conceptually closely related. Therefore, we assumed that the relationship between the state scale responses and task choice would hold even when the other applied trait variables (addressing the trait–state distinction) and state variables (addressing the discriminant validity) were controlled for.

## DEVELOPMENT OF THE STATE MEASURE

In order to assess a state rather than a trait, we rephrased the instruction and the 34 items of the German NFC scale (Bless et al., 1994). The changes were kept to a minimum. Afterwards, two experts and one non-expert in theory and findings on NFC appraised the new items with respect to whether they are suitable for measuring state motivation for cognitive effort. All three raters evaluated 14 items concordantly as suitable. Through discussion, out of these 14 items, the 10 best fitting items were selected. Selection of items was based on keeping the breadth of the construct, and whether content and language were in line with capturing a momentary state. In the following, we will refer to the new 10-item state scale as motivation for cognition (MFC) scale. The scale name was chosen because in classical motivation research, the term "motivation" refers to current motivational states as opposed to dispositional "needs" or "motives."

## STUDY 1

### Methods

#### Participants

The participants were 294 university students (73% female; $M_{age}$ = 22.11 years, $SD_{age}$ = 2.88) from two universities in Southern Germany. We excluded one additional participant who obviously did not follow the instruction of the MFC scale (the participant crossed out the instruction "at the moment" and changed it to "in general").

The students were recruited on campus or in lectures and asked to complete a brief paper-pencil questionnaire. By the time both studies were conducted, it was neither compulsory nor customary at the university where the studies were conducted to seek explicit ethical approval for a study asking for participants' self-reports on MFC, NFC, and task choice. Nevertheless, we carefully ensured that Study 1 and Study 2 were conducted in line with the ethical guidelines of the American Psychological Association (APA) and in full accordance with the ethical guidelines of the German Association of Psychologists (DGPs). In particular, we did not induce any negative states in the participants. Hence, we had no reasons to assume that our study would induce any negative states in the participants exceeding the normal risks of filling out a questionnaire. Also, written informed consent was obtained according to the guidelines of the German Psychological Society. Informed consent included information about (a) research object, (b) study procedure, (c) duration and allowance, (d) possible benefits of participation, (e) anonymity of data collection, and (f) possible risks of participation. Further, all participants were explicitly informed that participation was voluntary and could be terminated at any time without any reason or negative consequences for the participant. Participants had to declare that they were at least 18 years old, had read the informed consent, and agreed to the rules of participation.

#### Measures

We did not apply any additional measures in the present study than the ones mentioned in the following. The order of the three measures within the questionnaire was shuffled across participants. On its title page, the questionnaire also contained questions on personal data (age, gender, course of study). The Cronbach's αs and descriptive statistics in the present study are presented in **Table 1** and the Results section.

**TABLE 1 |** Item wordings and descriptive statistics of the motivation for cognition (MFC) scale in study 1.

| Item | Wording (English/*German*) | *M* | *SD* | λ | $r_{it}$ |
|---|---|---|---|---|---|
| 1. | Right now, I would really enjoy a task that involves coming up with new solutions to problems.<br>*Die Aufgabe, neue Lösungen für ein Problem zu finden, würde mir im Moment wirklich Spaß machen.* | 0.19 | 1.64 | 0.64 | 0.59 |
| 2. | Right now, I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.<br>*Ich würde im Moment lieber eine Aufgabe lösen, die Intelligenz erfordert, schwierig und bedeutend ist, als eine Aufgabe, die zwar irgendwie wichtig ist, aber nicht viel Nachdenken erfordert.* | −0.17 | 1.57 | 0.58 | 0.54 |
| 3. | If I read something that confuses me right now, I would just put it down and forget it. (R)<br>*Wenn ich jetzt etwas lesen würde, das mich verwirrt, dann würde ich es zur Seite legen und vergessen.* (R) | 0.23 | 1.81 | 0.55 | 0.52 |
| 4. | Right now, the notion of thinking abstractly is not appealing to me. (R)<br>*Abstrakt zu denken, reizt mich gerade nicht.* (R) | 0.07 | 1.74 | 0.60 | 0.57 |
| 5. | Right now, I prefer to think about small, daily projects to long-term ones. (R)<br>*Ich mag im Moment lieber über kleine, alltägliche Vorhaben nachdenken, als über langfristige.* (R) | −0.26 | 1.82 | 0.57 | 0.54 |
| 6. | Right now, I would rather do something that requires little thought than something that is sure to challenge my thinking abilities. (R)<br>*Ich mag im Moment lieber etwas tun, das wenig Denken erfordert, als etwas, das mit Sicherheit meine Denkfähigkeit herausfordert.* (R) | −0.08 | 1.73 | 0.80 | 0.74 |
| 7. | Right now, I would like to avoid situations where there is a likely chance I will have to think in depth about something. (R)<br>*Ich möchte jetzt gerade Situationen vermeiden, in denen die Wahrscheinlichkeit groß ist, dass ich intensiv über etwas nachdenken muss.* (R) | −0.04 | 1.69 | 0.84 | 0.78 |
| 8. | Right now, I would like to solve a puzzle.<br>*Jetzt gerade würde ich gerne eine knifflige Aufgabe lösen.* | −0.86 | 1.62 | 0.74 | 0.68 |
| 9. | Right now, I prefer complex to simple problems.<br>*In diesem Moment ziehe ich komplizierte Probleme einfachen Problemen vor.* | −0.99 | 1.54 | 0.66 | 0.61 |
| 10. | Right now, I would enjoy thinking about an issue even when the results of my thought would have no effect on the outcome of the issue.<br>*Es würde mir im Moment Spaß machen, über ein Problem nachzudenken, sogar dann, wenn die Ergebnisse meines Denkens keinen Einfluss auf die Lösung des Problems hätten.* | −0.57 | 1.69 | 0.58 | 0.54 |
| | MFC scale | −0.25 | 1.17 | | |

*N = 294. λ, factor loading; $r_{it}$, corrected item-total correlation; (R), item has to be recoded. Means were calculated after the respective items had been recoded. Items were responded on a scale from −3 (does not apply at all) to +3 (applies exactly). Exact wording of the instruction: "Please indicate how far the following statements apply to you personally in this moment".*

### *Motivation for Cognition*

State cognitive motivation was measured with our newly developed MFC scale. Participants answered each of the 10 items (e.g., "Right now, I prefer complex to simple problems"; for the wordings of all items, see **Table 1**) on a seven-point Likert-type scale from −3 (*does not apply at all*) to +3 (*applies exactly*). The instruction asked the participants to respond to the items as they applied in the present moment (i.e., "Please indicate how far the following statements apply to you personally *in this moment*").

### *Need for Cognition*

We used the established German brief version of the NFC scale (Bless et al., 1994). The brief scale consists of the 16 items from the German 33-item NFC scale that had the highest factor loadings in Bless et al. (1994). Participants completed the 16 items (e.g., "I tend to set goals that can be accomplished only by expending considerable mental effort") on seven-point Likert-type scales from −3 (*does not apply at all*) to +3 (*applies exactly*). Participants were instructed to indicate on the items how each statement applies to them in general.

### *Choice of Task Difficulty Item*

Participants were asked to indicate which difficulty level they would choose for a completely unspecified task that would immediately follow the present questionnaire. They could choose one of six different difficulty levels: Level 1 was described as requiring very low cognitive effort, level 2 as requiring low cognitive effort, level 3 as requiring somewhat low cognitive effort, level 4 as requiring somewhat high cognitive effort, level 5 as requiring high cognitive effort, and level 6 as requiring very high cognitive effort. Thus, the higher the chosen difficulty level was, the higher the cognitive effort one was motivated to exert in the present situation. Similar measures for state task motivation have been used in previous research (Finkel et al., 2006; Bertrams and Dickhäuser, 2010). We used the number of the chosen difficulty level for data analyses. Actually, the participants did not

receive any task after finishing the questionnaire. A translated version of this measure is presented in **Appendix A**.

## Results and Discussion

### Factor Structure

The Kaiser–Meyer–Olkin measure of sampling adequacy (Kaiser, 1970), $KMO = 0.90$, and the statistical significance of Bartlett (1954) test of sphericity, $p < 0.001$, indicated that the present data were suitable for factor analysis. First, we determined the number of factors by applying the scree test (Cattell and Vogelmann, 1977) and the minimum average partial (MAP) test (Velicer, 1976). As the MAP test is superior to the scree test in terms of objectivity and reliability (O'Connor, 2000), we intended to weigh the solution from the MAP test more strongly. To run the (revised) MAP test, we used O'Connor's SPSS syntax (retrieved from https://people.ok.ubc.ca/brioconn/nfactors/nfactors.html on September 23, 2014; see also O'Connor, 2000). Afterwards, we conducted a principal axis factor analysis, as recommended by Russell (2002).

Both the results of the scree test and the MAP test indicated a one-factor solution for the MFC scale (initial eigenvalues: 4.90, 1.22, 0.73, 0.65, 0.58, 0.54, 0.46, 0.39, 0.28, 0.26). The subsequent principal axis factor analysis revealed that the extracted single factor explained a total of 43.71% of the variance of MFC. All 10 items loaded sufficiently high (defined as $\lambda > 0.32$; Tabachnick and Fidell, 2007) on this factor, $\lambda s > 0.54$ (see **Table 1**). Thus, it emerged that MFC, as measured by the MFC scale, is a one-dimensional construct.

### Descriptive Statistics and Reliability

**Table 1** provides means and standard deviations for the single items and the total scale. Moreover, the corrected item-total correlations are given, which were all reasonably high, $r_{it}s > 0.51$. Visual inspection of the scale value-frequency histogram and the normal Q–Q plot of the scale values revealed that the total scale values were normally distributed. There were no outliers in the present sample because no total scale value exceeded the critical $z$-value of $\pm 3.29$, $z_{min} = -2.35$, $z_{max} = 2.17$ (for testing for normality and outliers, see Tabachnick and Fidell, 2007). The inner consistency of the scale can be considered as high, Cronbach's $\alpha = 0.88$, speaking for the reliability of the MFC scale. Furthermore, the average inter-item correlation of 0.43 was slightly outside the interval of [20, 40] recommended by Briggs and Cheek (1986), suggesting that the MFC scale measures a quite homogenous construct.

### Validity

As expected, MFC correlated positively with NFC, $r = 0.51$, $p < 0.001$, two-tailed (descriptive statistics for NFC in the present sample: $M = 0.88$, $SD = 0.78$, $\alpha = 0.85$). Although this correlation can be considered as high (Cohen, 1988), it is far from determining that MFC and NFC are identical. Moreover, in accordance with our prediction, MFC was positively correlated with chosen task difficulty, $r = 0.56$, $p < 0.001$, two-tailed (descriptive statistics for the task choice item in the present sample: $M = 3.46$, $SD = 1.06$).

Next, applying multiple regression analysis, we regressed task choice on MFC and NFC as simultaneous predictors. Whereas, MFC significantly and strongly predicted task choice over and above NFC, $B = 0.46$, $SE\ B = 0.05$, $\beta = 0.51$, $t = 9.15$, $p < 0.001$, two-tailed, NFC was not significantly related to task choice, $B = 0.14$, $SE\ B = 0.08$, $\beta = 0.11$, $t = 1.87$, $p = 0.06$, two-tailed [overall model: $F_{(2,291)} = 70.51$, $p < 0.001$, $R^2_{adj} = 0.32$]. In sum, Study 1 yielded initial evidence for the validity and utility of the MFC scale.

# STUDY 2

## Methods

### Participants

The participants were recruited via non-public student mailing lists. In an email, recipients were asked to participate in an online study, and a link to the study was provided. Ninety-eight individuals clicked the link that led them to the welcome page of the study; 80 of them (60% female; $M_{age} = 25.08$ years; $SD_{age} = 4.08$) completed all measures (including questions about gender and age at the end of the study). Several individuals stopped their participation at some point during data collection. As the *N*s for the MFC scale and the validation measures therefore vary (see **Table 2**), so do the *N*s of the reported analyses (see the respective Table notes).

### Measures

In the following, we mention all measures that we applied. The measures were presented via computer, each appearing on a separate page. The computer software (Unipark) randomly determined the order of their appearance, except for the choice task and the demographic data questions which were presented at the end of the survey. The Cronbach's αs in the present study are shown in **Table 2**.

#### *Motivation for Cognition and Need for Cognition*

Motivation for cognition and NFC were measured with the same scales as in Study 1.

#### *Hope of Success and Fear of Failure*

We used the revised brief Achievement Motives Scale for German-speaking samples (Lang and Fries, 2006) to measure hope of success with five items (e.g., "I am attracted to situations allowing me to test my abilities") and fear of failure with five items (e.g., "Even if nobody notices my failure, I'm afraid of tasks which I'm not able to solve"). The statements were answered on four-point Likert-type scales from 1 (*not true at all*) to 4 (*absolutely true*), and as to how they apply to one in general.

#### *Self-Control Capacity*

The German brief version of the State Self-Control Capacity Scale (Bertrams et al., 2011) was employed. The scale consists of 10 items (e.g., "I feel sharp and focused") that the participants completed on Likert-type scales from 1 (*does not apply at all*) to 7 (*applies exactly*), with respect to the present moment.

**TABLE 2 |** Descriptive statistics and intercorrelations of the applied measures in study 2.

| Measure | Dimension of measurement | *n* | *M* | *SD* | α | Intercorrelations | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. Motivation for cognition | State | 87 | 3.72 | 1.29 | 0.92 | – | | | | | | | |
| 2. Need for cognition | Trait | 82 | 4.82 | 0.77 | 0.86 | 0.51*** | – | | | | | | |
| 3. Hope of success | Trait | 89 | 3.26 | 0.44 | 0.73 | 0.23* | 0.48*** | – | | | | | |
| 4. Fear of failure | Trait | 89 | 2.39 | 0.64 | 0.81 | −0.45*** | −0.44*** | −0.10 | – | | | | |
| 5. Self-control capacity | State | 88 | 4.50 | 1.16 | 0.88 | 0.59*** | 0.26* | 0.04 | −0.37*** | - | | | |
| 6. Subjective vitality | State | 91 | 3.72 | 1.45 | 0.93 | 0.57*** | 0.28* | 0.21 | −0.32** | 0.73*** | - | | |
| 7. Positive affect | State | 87 | 2.58 | 0.67 | 0.85 | 0.57*** | 0.29** | 0.30** | −0.20 | 0.59*** | 0.70*** | - | |
| 8. Negative affect | State | 87 | 1.56 | 0.66 | 0.88 | −0.25* | −0.27* | −0.19 | 0.43*** | −0.52*** | −0.53*** | −0.30** | - |
| 9. Choice of task difficulty | State | 82 | 3.43 | 1.41 | – | 0.43*** | 0.44*** | 0.37*** | −0.25* | −0.42*** | 0.41*** | 0.24* | −0.28* |

*Ns for intercorrelations: 82–89. Overall scores of a psychometric scale were obtained by averaging the responses to the scale items.*
*$^{*}p < 0.05$, two-tailed. $^{**}p < 0.01$, two-tailed. $^{***}p < 0.001$, two-tailed.*

### *Subjective Vitality*

Participants indicated their momentarily perceived vitality on the six items of the German state version of the Subjective Vitality Scale (Bertrams et al., 2020). A sample item was "I feel alive and vital." Answers were given on seven-point Likert-type scales from 1 (*does not apply at all*) to 7 (*applies exactly*).

### *Positive and Negative Affect*

With the German adaptation of the Positive and Negative Affect Schedule (Krohne et al., 1996), we measured momentary mood. Participants indicated how they felt at the moment on 10 items for positive affect (e.g., "excited") and another 10 items for negative affect (e.g., "nervous"). All 20 items were responded to on scales from 1 (*not at all*) to 5 (*extremely*).

### *Choice of Task Difficulty Item*

After answering the motivational and affective measures, the participants were informed that the next page would contain five anagrams that they would be asked to solve. With the help of two examples, it was explained to them that an anagram is a scrambled word that has to be rearranged into a meaningful German word [e.g., EMRE to MEER (engl.: sea); EIGLESE to SEEIGEL (engl.: sea urchin)]. In addition, the participants read that it would be up to them to select their level of difficulty of the anagrams. There would be six levels of difficulty, depending on the number of letters each anagram word consists of, and higher levels would be mentally more effortful to solve. The participants then could choose between difficulty level A (three letters), B (four letters),…, and F (eight letters) (Note that unlike some countries, in Germany, grades are *not* assigned as letters between A and F but as numbers; therefore, for our German participants, the labeling of the difficulty levels was not confounded with the common evaluation of achievement). For the purpose of data analyses, we coded a selection of level A as 1, of level B as 2, and so forth. A translated version of this measure is presented in **Appendix B**.

After the participants had chosen one difficulty level and clicked on "continue", they were debriefed on a newly appearing page that informed them that, in fact, no anagram task would take place because for the present study, it was only of interest as to how motivated people are at the moment to solve rather difficult anagrams. We informed them about a website that provides puzzles, including anagrams; after assessment of personal data and offered the respective weblink.

**TABLE 3 |** Multiple regression analysis for predicting choice of task difficulty by motivation for cognition and trait measures in study 2.

| Predictor | *B* | *SE B* | β | *t* | *p*[a] |
|---|---|---|---|---|---|
| Motivation for cognition | 0.29 | 0.13 | 0.26 | 2.23 | 0.03 |
| Need for cognition | 0.35 | 0.24 | 0.19 | 1.47 | 0.15 |
| Hope of success | 0.66 | 0.34 | 0.21 | 1.92 | 0.06 |
| Fear of failure | −0.05 | 0.25 | −0.02 | −0.21 | 0.83 |

*$N = 82$.*
*[a] Two-tailed.*

## Results and Discussion

**Table 2** shows the descriptive statistics for the applied measures and how they were intercorrelated. Again, the MFC scale displayed good internal consistency (Cronbach's $\alpha = 0.92$). As can be seen in **Table 2**, responses to the MFC scale were significantly related to the validity criteria, each in the expected direction. Thus, the bivariate correlations provide evidence for the validity of the MFC scale because all relationships were predefined from a theoretical base.

The MFC scale was superior to the other applied trait and state measures in predicting anagram task choice, as multiple regression analyses revealed (see **Tables 3**, **4**). As expected, over and above trait measures, MFC significantly predicted the cognitive effort in an ostensibly subsequent task that participants were motivated to invest in (see **Table 3**). In contrast, the significant bivariate relations NFC and achievement motives had with task choice (**Table 2**) vanished when MFC was accounted for in the same model; overall model: $F_{(4,77)} = 7.53$, $p < 0.001$, $R^2_{adj} = 0.24$, two-tailed. The trait measures including NFC may be

**TABLE 4 |** Multiple regression analysis for predicting choice of task difficulty by motivation for cognition and other state measures in study 2.

| Predictor | *B* | *SE B* | β | *t* | *p*[a] |
|---|---|---|---|---|---|
| Motivation for cognition | 0.32 | 0.15 | 0.29 | 2.15 | 0.04 |
| Self-control capacity | 0.21 | 0.19 | 0.17 | 1.10 | 0.28 |
| Subjective vitality | 0.21 | 0.17 | 0.22 | 1.25 | 0.21 |
| Positive affect | −0.41 | 0.31 | −0.20 | −1.36 | 0.18 |
| Negative affect | −0.11 | 0.26 | −0.05 | −0.42 | 0.68 |

*N* = 82.
[a] *Two-tailed.*

seen as distal measures of cognitive motivation and their bivariate relations to task choice may be attributable to the variance they share with MFC.

An additional multiple regression analysis showed that the MFC scale also predicted the chosen cognitive effort in the anagram task over and above the other state measures (see **Table 4**). The relations of self-control capacity, subjective vitality, and mood with task choice (**Table 2**) did not hold over and above MFC. The overall model was significant; $F_{(5,76)} = 5.21$, $p < 0.001$, $R^2_{adj} = 0.21$, two-tailed. Thus, in support of its validity, the MFC scale was the state measure that best predicted a behavioral indicator of cognitive motivation, which was independent from momentary experience not directly defining cognitive motivation (e.g., subjective vitality).

## GENERAL DISCUSSION

The aim of the present work was to find evidence that a state measure of the momentary motivation to engage in effortful cognition would usefully add to the existing measure of trait NFC. For this purpose, we developed the MFC scale and intended to show initial evidence that state cognitive motivation can reliably and validly be measured. The central findings from two studies can be summarized as follows. The MFC scale captures a unidimensional construct and is a reliable measure in terms of internal consistency. Furthermore, the scale is valid in terms of being theoretically meaningfully related to other measures—that is, hope of success and fear of failure (Lang and Fries, 2006), self-control capacity (Bertrams et al., 2011), subjective vitality (Bertrams et al., 2020), positive and negative affect (Krohne et al., 1996), NFC (Bless et al., 1994), and choice of task difficulty. Finally, the MFC scale is superior to related trait and state measures in predicting momentary motivation to engage in cognitive effort. In sum, our findings preliminarily indicate that the new MFC scale is a psychometrically sound measure.

There are numerous ways to apply the MFC scale in research and practice. For instance, the effect of low momentary relative to dispositional motivation to engage in cognitive effort on using stereotypes (Dudley and Harris, 2003) may be more pronounced. For several reasons, someone who is usually highly motivated for cognitive effort (i.e., high in NFC) might not be so during each experimental session; the reverse may also be true for someone low in NFC. Therefore, application of the MFC scale for measuring state cognitive motivation may enable researchers to test their respective hypotheses with more statistical power. Further, since intrinsically motivated learning is highly affected by a large set of situational and intrapersonal variables (Heckhausen and Heckhausen, 2018), motivational shifts toward and against cognitive effort may occur along with a variety of combined factors given the specific learning situation. Eventually, a state measure assessing student's momentary motivation for cognitive effort may be useful in school intervention studies. In educational counseling or clinical therapy, the MFC scale may function as a control of testees' motivation to complete cognitively effortful diagnostic instruments (e.g., tests of cognitive abilities).

This leads us to an interesting point. The relationship between NFC and intelligence has usually been found to be small, if existent at all (Cacioppo et al., 1996; Fleischhauer et al., 2010; Preckel, 2014). This has been interpreted such that NFC is a motivational—rather than an ability—construct (Cacioppo et al., 1996). It is, however, quite implausible that the motivation to spend cognitive effort does not affect how one performs in a cognitively challenging test. The lack of evidence for a substantial relation between cognitive motivation and intelligence may, in part, be attributable to the unequal dimensions on which both variables were assessed. Cognitive motivation was measured on the trait level (i.e., with the NFC scale), whereas intelligence was inferred from a specific performance situation. Possibly, the relationship between cognitive motivation and cognitive ability is larger than previously found when the dimensions of assessment match (i.e., when the MFC scale is applied directly before the intelligence test). In this context, one might also want to address the question of how typical vs. maximal performance in intelligence tests is related to state motivation for cognitive effort similar to previous studies of NFC and Motivation (e.g., Klehe and Anderson, 2007; Von Stumm, 2013). Examining the relation between the momentary motivation to invest cognitive effort and intelligent performance is an exciting direction for future research.

Furthermore, one can assume that such a measure could serve well in diary or experience sampling designs. In a diary study, for example, the use of the MFC scale may provide insights into how motivation for cognitive effort manifests itself over different times of the day, in various working group constellations, or in relation to different types of tasks and their specific characteristics. In sum, future research could aim to investigate structural and situational factors in the work or study environment linked to MFC and its relevant outcomes.

Our findings also add to the evidence of good psychometric properties of the NFC scale (e.g., Bless et al., 1994; Cacioppo et al., 1996; Bertrams and Dickhäuser, 2010). Similar to the MFC scale, the NFC scale was meaningfully related to all validity criteria in the present studies. To examine relationships on the dispositional level, the NFC scale—rather than the MFC scale—may be the appropriate measure. Moreover, when there is a larger time lag between the assessment of cognitive motivation and of other variables in a study, the NFC scale may be of exceptional use. For instance, researchers may sometimes like to measure cognitive motivation several weeks prior to an experiment to avoid having participants suspect the underlying hypothesis. In such cases, it would not make much sense to apply a state measure of motivation for cognitive effort, but rather the NFC scale.

However, when it is important to assess cognitive motivation as it exists in a concrete situation, the MFC scale may often be the more accurate measure.

Some limitations of the present study deserve attention. For instance, a criterion we didn't address was the MFC scale's sensitivity to change (e.g., its responsiveness; Husted et al., 2000). One can assume, that a person's MFC changes on a daily basis due to mental fatigue fluctuations (for a detailed overview on fatigue see, van der Linden, 2011) or simply not being in the mood for applying cognitive effort. Therefore, further research is needed to establish the MFC scale's sensitivity regarding changes in individuals' willingness to exert cognitive effort in different contexts. This could either be realized by repeated measures over time (e.g., Wilhelm and Schoebi, 2007) or by experimentally manipulating conditions, e.g., mood induction procedures (MIP) (see Westermann et al., 1996). In addition, longitudinal designs would allow to capture the trait- and state-specific components of MFC, e.g., by applying latent state–trait (LST) models (Steyer et al., 1999). Another important direction for future research could be to highlight the state–trait difference by showing significant temporal variance in MFC and relative stability in NFC. Last, generalizability of findings is limited to the characteristics of the sample studied, namely German university students of a certain age group with comparable educational backgrounds. It remains to be investigated whether the MFC scale is also a valid and reliable instrument in non-student samples or among children and adolescents as has been done previously with the NFC-Scale (e.g., Preckel, 2014; Keller et al., 2019).

## CONCLUSIONS

Even though we consider our findings preliminary, this article provides initial evidence for a valid and reliable measurement of MFC from a state perspective as well as useful recommendations for scientific implementation.

## DATA AVAILABILITY STATEMENT

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

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

TM and AB: developed the study concept and design and collected data. AB and MB: analyzed, interpreted the data, and prepared the draft manuscript. AK and TM: provided critical revisions. All authors contributed meaningfully to the paper, approve the final version to be published, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.785094/full#supplementary-material

## REFERENCES


Bartlett, M. S. (1954). A note on the multiplying factors for various chi square approximations. *J. Roy. Stat. Soc. B* 16, 296–298. doi: 10.1111/j.2517-6161.1954.tb00174.x

Bertrams, A., and Dickhäuser, O. (2009). High-school students' need for cognition, self-control capacity, and school achievement: testing a mediation hypothesis. *Learn. Individ. Differ.* 19, 135–138. doi: 10.1016/j.lindif.2008.06.005

Bertrams, A., and Dickhäuser, O. (2010). University and school students' motivation for effortful thinking: factor structure, reliability, and validity of the German need for cognition scale. *Eur. J. Psychol. Assess.* 26, 263–268. doi: 10.1027/1015-5759/a000035

Bertrams, A., and Dickhäuser, O. (2012). Passionate thinkers feel better: self-control capacity as mediator of the relationship between need for cognition and affective adjustment. *J. Indiv. Diff.* 33, 69–75. doi: 10.1027/1614-0001/a000081

Bertrams, A., Dyllick, T. H., Englert, C., and Krispenz, A. (2020). German adaptation of the Subjective Vitality Scales (SVS-G). *Open Psychol.* 2, 57–75. doi: 10.1515/psych-2020-0005

Bertrams, A., Unger, A., and Dickhäuser, O. (2011). Momentan verfügbare Selbstkontrollkraft-Vorstellung eines Messinstruments und erste Befunde aus pädagogisch-psychologischen Kontexten [Momentarily available self-control strength-Introduction of a measure and first findings from educationalpsychological contexts]. *Z. Pädagog. Psychol. [Ger. J. Educ. Psychol.]* 25, 185–196. doi: 10.1024/1010-0652/a000042

Bless, H., Bohner, G., Fellhauer, R. F., and Schwarz, N. (1994). Need for Cognition: Eine Skala zur Erfassung von Engagement und Freude bei Denkaufgaben [Need for cognition: a scale measuring engagement and happiness in cognitive tasks]. *Z. Sozialpsychol.* [*Ger. J. Soc. Psychol.*] 25, 147–154.

Briggs, S. R., and Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *J. Pers.* 54, 106–148. doi: 10.1111/j.1467-6494.1986.tb00391.x

Cacioppo, J. T., and Petty, R. E. (1982). The need for cognition. *J. Pers. Soc. Psychol.* 42, 116–131. doi: 10.1037/0022-3514.42.1.116

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., and Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: the life and times of individuals varying in need for cognition. *Psychol. Bull.* 119, 197–253. doi: 10.1037/0033-2909.119.2.197

Cacioppo, J. T., Petty, R. E., Kao, C. F., and Rodriguez, R. (1986). Central and peripheral routes to persuasion: an individual difference perspective. *J. Pers. Soc. Psychol.* 51, 1032–1043. doi: 10.1037/0022-3514.51.5.1032

Carnevale, J. J., Inbar, Y., and Lerner, J. S. (2011). Individual differences in need for cognition and decision-making competence among leaders. *Pers. Individ. Dif.* 51, 274–278. doi: 10.1016/j.paid.2010.07.002

Cattell, R. B., and Vogelmann, S. (1977). A comprehensive trial of the scree and KG criteria for determining the number of factors. *Multivariate Behav. Res.* 12, 289–325. doi: 10.1207/s15327906mbr1203_2

Clark, R. A., Teevan, R., and Ricciuti, H. N. (1956). Hope of success and fear of failure as aspects of need for achievement. *J. Abnorm. Soc. Psychol.* 53, 182–186. doi: 10.1037/h0046496

Cohen, J. W. (1988). *Statistical Power Analysis for the Behavioral Sciences, 2nd Edn.* New York, NY: Lawrence Erlbaum Associates.

Curşeu, P. L. (2011). Need for cognition and active information search in small student groups. *Learn. Individ. Differ.* 21, 415–418. doi: 10.1016/j.lindif.2011.02.005

Davis, T. L., Severy, L. J., Kraus, S. L., and Whitaker, J. M. (1993). Predictors of sentencing decisions: the beliefs, personality variables, and demographic factors of juvenile justice personnel. *J. Appl. Soc. Psychol.* 23, 451–477. doi: 10.1111/j.1559-1816.1993.tb01098.x

Drolet, A., Luce, M. F., and Simonson, I. (2009). When does choice reveal preference? Moderators of heuristic versus goal-based choice. *J. Consum. Res.* 36, 137–147. doi: 10.1086/596305

Dudley, M. G., and Harris, M. J. (2003). To think or not to think: the moderating role of need for cognition in expectancy-consistent impression formation. *Pers. Individ. Dif.* 35, 1657–1667. doi: 10.1016/S0191-8869(02)00388-4

Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment and social cognition. *Annu. Rev. Psychol.* 59, 255–278. doi: 10.1146/annurev.psych.59.103006.093629

Finkel, E. J., Dalton, A. N., Campbell, W. K., Brunell, A. B., Scarbeck, S. J., and Chartrand, T. L. (2006). High-maintenance interaction: inefficient social coordination impairs self-regulation. *J. Pers. Soc. Psychol.* 91, 456–475. doi: 10.1037/0022-3514.91.3.456

Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., and Strobel, A. (2010). Same or different? Clarifying the relationship of need for cognition to personality and intelligence. *Pers. Soc. Psychol. Bull.* 36, 82–96. doi: 10.1177/0146167209351886

Fleischhauer, M., Strobel, A., and Strobel, A. (2015). Directly and indirectly assessed need for cognition differentially predict spontaneous and reflective information processing behavior. *J. Indiv. Diff.* 36, 101–109. doi: 10.1027/1614-0001/a000161

Fridhandler, B. M. (1986). Conceptual note on state, trait, and the state–trait distinction. *J. Pers. Soc. Psychol.* 50, 169–174. doi: 10.1037/0022-3514.50.1.169

Gillet, N., Vallerand, R. J., Lafrenière, M.-A. K., and Bureau, J. S. (2013). The mediating role of positive and negative affect in the situational motivation-performance relationship. *Motiv. Emot.* 37, 465–479. doi: 10.1007/s11031-012-9314-5

Gogol, K., Brunner, M., Goetz, T., Martin, R., Ugen, S., Keller, U., et al. (2014). "My questionnaire is too long!" The assessments of motivational-affective constructs with three-item and single-item measures. *Contemp. Educ. Psychol.* 39, 188–205. doi: 10.1016/j.cedpsych.2014.04.002

Grass, J., John, N., and Strobel, A. (2018). Freude am Denken als Schlüssel zum Erfolg? Die Bedeutung von Need for Cognition für subjektives Erleben und Leistung im Studium [The joy of thinking as the key to success? The importance of need for cognition for subjective experience and achievement in academic studies]. *Z. Pädagog. Psychol. [Ger. J. Educ. Psychol.]* 32, 145–154. doi: 10.1024/1010-0652/a000222

Harman, J. L. (2011). Individual differences in need for cognition and decision making in the Iowa Gambling Task. *Pers. Individ. Dif.* 51, 112–116. doi: 10.1016/j.paid.2011.03.021

Heckhausen, H., and Heckhausen, J. (2018). "Motivation und Handeln: Einführung und Überblick [Motivation and action: introduction and overview]," in *Motivation und Handeln, 5. Aufl [Motivation and action, 5th Edn.],* eds H. Heckhausen and J. Heckhausen (Berlin: Springer), 1–12. doi: 10.1007/978-3-662-53927-9_1

Husted, J. A., Cook, R. J., Farewell, V. T., and Gladman, D. D. (2000). Methods for assessing responsiveness: a critical review and recommendations. *J. Clin. Epidemiol.* 53, 459–468. doi: 10.1016/S0895-4356(99)00206-1

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika* 35, 401–415. doi: 10.1007/BF02291817

Kasser, T., and Ryan, R. M. (1996). Further examining the American dream: differential correlates of intrinsic and extrinsic goals. *Pers. Soc. Psychol. Bull.* 22, 280–287. doi: 10.1177/0146167296223006

Keller, U., Strobel, A., Wollschläger, R., Greiff, S., Martin, R., Vainikainen, M. P., et al. (2019). A need for cognition scale for children and adolescents. Structural analysis and measurement invariance. *Eur. J. Psychol. Assess.* 35, 137–149. doi: 10.1027/1015-5759/a000370

Klehe, U. C., and Anderson, N. (2007). Working hard and working smart: motivation and ability during typical and maximum performance. *J. Appl. Psychol.* 92, 978–992. doi: 10.1037/0021-9010.92.4.978

Kramer, A. W., Van Duijvenvoorde, A. C., Krabbendam, L., and Huizenga, H. M. (2021). Individual differences in adolescents' willingness to invest cognitive effort: relation to need for cognition, motivation and cognitive capacity. *Cogn. Dev.* 57:100978. doi: 10.1016/j.cogdev.2020.100978

Krohne, H. W., Egloff, B., Kohlmann, C.-W., and Tausch, A. (1996). Untersuchungen mit einer deutschen Version der "Positive and Negative Affect Schedule" (PANAS) [Investigations with a German version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica* 42, 139–156. doi: 10.1037/t49650-000

Lang, J. W. B., and Fries, S. (2006). A revised 10-item version of the achievement motives scale: psychometric properties in German-speaking samples. *Eur. J. Psychol. Assess.* 22, 216–224. doi: 10.1027/1015-5759.22.3.216

Luong, C., Strobel, A., Wollschläger, R., Greiff, S., Vainikainen, M. P., and Preckel, F. (2017). Need for cognition in children and adolescents: behavioral correlates and relations to academic achievement and potential. *Learn. Individ. Differ.* 53, 103–113. doi: 10.1016/j.lindif.2016.10.019

Maloney, E. A., and Retanal, F. (2020). Higher math anxious people have a lower need for cognition and are less reflective in their thinking. *Acta Psychol.* 202:102939. doi: 10.1016/j.actpsy.2019.102939

Masicampo, E. J., and Baumeister, R. F. (2008). Toward a physiology of dual-process reasoning and judgment: lemonade, willpower, and expensive rule-based analysis. *Psychol. Sci.* 19, 255–260. doi: 10.1111/j.1467-9280.2008.02077.x

Meier, E., Vogl, K., and Preckel, F. (2014). Motivational characteristics of students in gifted classes: the pivotal role of need for cognition. *Learn. Individ. Differ.* 33, 39–46. doi: 10.1016/j.lindif.2014.04.006

Newman, L. S. (1996). Trait impressions as heuristics for predicting future behavior. *Pers. Soc. Psychol. Bull.* 22, 395–411. doi: 10.1177/0146167296224006

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behav. Res. Methods Instrum. Comput.* 32, 396–402. doi: 10.3758/BF03200807

Pocheptsova, A., Amir, O., Dhar, R., and Baumeister, R. F. (2009). Deciding without resources: resource depletion and choice in context. *J. Market. Res.* 46, 344–355. doi: 10.1509/jmkr.46.3.344

Pohl, R. F., Erdfelder, E., Hilbig, B. E., Liebke, L., and Stahlberg, D. (2013). Effort reduction after self-control depletion: the role of cognitive resources in use of simple heuristics. *J. Cogn. Psychol.* 25, 267–276. doi: 10.1080/20445911.2012.758101

Preckel, F. (2014). Assessing need for cognition in early adolescence: validation of a German adaption of the Cacioppo/Petty scale. *Eur. J. Psychol. Assess.* 30, 65–72. doi: 10.1027/1015-5759/a000170

Preckel, F., Holling, H., and Vock, M. (2006). Academic under-achievement: relationship with cognitive motivation, achievement motivation, and conscientiousness. *Psychol. Sch.* 43, 401–411. doi: 10.1002/pits.20154

Rudolph, J., Greiff, S., Strobel, A., and Preckel, F. (2018). Understanding the link between need for cognition and complex problem solving. *Contemp. Educ. Psychol.* 55, 53–62. doi: 10.1016/j.cedpsych.2018.08.001

Russell, D. W. (2002). In search of underlying dimensions: the use (and abuse) of factor analysis in Personality and Social Psychology Bulletin. *Pers. Soc. Psychol. Bull.* 28, 1629–1646. doi: 10.1177/0146167022 37645

Ryan, R. M., and Frederick, C. M. (1997). On energy, personality and health: subjective vitality as a dynamic reflection of well-being. *J. Pers.* 65, 529–565. doi: 10.1111/j.1467-6494.1997.tb00326.x

Schindler, J., Schindler, S., and Reinhard, M. A. (2019). Effectiveness of self-generation during learning is dependent on individual differences in need for cognition. *Front. Learn. Res.* 7, 23–39. doi: 10.14786/flr.v7i2.407

Spielberger, C. D., Gorsuch, R. L., and Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., and Vagg, P. R. (1995). "Test anxiety: a transactional process model," in *Test anxiety: Theory, Assessment, and Treatment,* eds C. D. Spielberger and P. R. Vagg (Washington, DC: Taylor and Francis), 3–14.

Steyer, R., Schmitt, M., and Eid, M. (1999). Latent state–trait theory and research in personality and individual differences. *Eur. J. Pers.* 13, 389–408.

doi: 10.1002/(SICI)1099-0984(199909/10)13:5<389::AID-PER361>3.0.CO;2-A

Tabachnick, B. G., and Fidell, L. S. (2007). *Using Multivariate Statistics, 5th Edn.* New York, NY: Allyn and Bacon.

Tanaka, J. S., Panter, A., and Winborne, W. C. (1988). Dimensions of the need for cognition: subscales and gender differences. *Multivar. Behav. Res.* 23, 35–50. doi: 10.1207/s15327906mbr2301_2

Tormala, Z. L., and Clarkson, J. J. (2008). Source trustworthiness and information processing in multiple message situations: a contextual analysis. *Soc. Cogn.* 26, 357–367. doi: 10.1521/soco.2008.26.3.357

Unnikrishnan Nair, K., and Ramnarayan, S. (2000). Individual differences in need for cognition and complex problem solving. *J. Res. Pers.* 34, 305–328. doi: 10.1006/jrpe.1999.2274

van der Linden, D. (2011). "The urge to stop: the cognitive and biological nature of acute mental fatigue," in *Cognitive Fatigue: Multidisciplinary Perspectives on Current Research and Future*, ed P. L. Ackerman (Washington, DC: American Psychological Association), 149–160. doi: 10.1037/12343-007

Velicer, W. F. (1976). Determining the number of components from the matrix of partial correlations. *Psychometrika* 41, 321–327. doi: 10.1007/BF02293557

Von Stumm, S. (2013). Investment traits and intelligence in adulthood. *J. Indiv. Diff.* 34, 82–98. doi: 10.1027/1614-0001/a000101

Watson, D., Clark, L. A., and Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *J. Pers. Soc. Psychol.* 54, 1063–1070. doi: 10.1037/0022-3514.54.6.1063

Westbrook, A., and Braver, T. S. (2015). Cognitive effort: a neuroeconomic approach. *Cogn. Affect. Behav. Neurosci.* 15, 395–415. doi: 10.3758/s13415-015-0334-y

Westbrook, A., Kester, D., and Braver, T. S. (2013). What is the subjective cost of cognitive effort? Load, trait, and aging effects revealed by economic preference. *PLoS ONE* 8, e68210. doi: 10.1371/journal.pone.0068210

Westermann, R., Spies, K., Stahl, G., and Hesse, F. W. (1996). Relative effectiveness and validity of mood induction procedures: a meta-analysis. *Eur. J. Soc. Psychol.* 26, 557–580. doi: 10.1002/(SICI)1099-0992(199607)26:4<557::AID-EJSP769>3.0.CO;2-4

Wilhelm, P., and Schoebi, D. (2007). Assessing mood in daily life. Structural validity, sensitivity to change, and reliability of a short-scale to measure three basic dimensions of mood. *Eur. J. Psychol. Assess.* 23, 258–267. doi: 10.1027/1015-5759.23.4.258

Zhang, Y. (1996). Responses to humorous advertising: the moderating effect of need for cognition. *J. Advert.* 25, 15–32. doi: 10.1080/00913367.1996.10673493

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# My Precious: Development and Validation of the Conservation of Human Energy Resources Index (CHER-I)

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# My Precious: Development and Validation of the Conservation of Human Energy Resources Index (CHERI)

Conserving energy resources is crucial for sustaining effort and preventing exhaustion, especially in demanding work environments. Yet, a reliable and valid measure for assessing individuals' motivation to conserve energy is currently lacking. To fill this gap, we introduce a concise five-item scale, the Conservation of Human Energy Resources Index (CHERI), available in both German (CHERI-G) and English (CHERI-E) versions. In four comprehensive studies ($N$ = 1,814), we evaluated the structure and psychometric properties of both language versions. Our results reveal that the CHERI measures a one-dimensional, homogeneous construct characterized by a high internal consistency (Studies 1, 2, and 4). Our findings also emphasize the CHERI's sensitivity to change (Study 3) and its meaningful associations with measures from the nomological network of motivation, energy, and effort (Studies 2 and 4). Additionally, we demonstrate the cross-cultural equivalence of the CHERI-G and CHERI-E as well as their equivalence across situational contexts, encompassing both workplace and academic settings (Study 4). Taken together, the present research provides compelling evidence for the psychometric soundness of the CHERI, which can be used to enhance our understanding of energy conservation behaviors and to open new perspectives for advancing energy management and recovery research.

Keywords: *effort investment; energy conservation; measurement; motivation; resource mobilization; scale development*

## Introduction

Effective utilization of energy resources is a fundamental aspect of human behavior, influenced by both dispositional tendencies and situational factors. From a dispositional standpoint, individuals inherently seek to conserve energy and avoid unnecessary expenditure, a principle deeply ingrained in human psychology (Westbrook et al., 2013; Kool et al., 2010). This inclination towards energy conservation ensures that individuals allocate just enough energy resources to achieve their goals while avoiding depletion (Gendolla & Richter, 2010).

Beyond this dispositional aspect, understanding how situational and intrapersonal factors shape energy conservation behaviors is essential for the following reasons. In dynamic contexts such as the workplace, individuals encounter various factors influencing their energy investment decisions. Task difficulty, time constraints, perceived costs and benefits, and the subjective value of tasks all contribute to the complex calculus of effort and energy allocation (e.g., Boksem & Tops, 2008; Brehm & Self, 1989; Chevalier, 2017; Gray et al., 2006; Kurzban et al., 2013). This multitude of factors triggering conservation or mobilization of energy underscores the importance of investigating motivation to conserve energy as a momentary state. For instance, in a professional setting, effective management of personal energy resources plays a pivotal role in navigating challenging job demands such as increased workloads or work stress (e.g., Fritz et al., 2013). Thus, strategically deployed energy conservation may promote factors associated with mental health and occupational well-being, including vitality, fatigue, exhaustion, and effective recovery (e.g., Kinnunen et al., 2015; Quinn et al., 2012; Parker et al., 2017; Sonnentag et al., 2022).

At present, however, conclusions about the situational motivation to conserve energy are often indirectly drawn from research on variables such as effort exertion, depletion, fatigue, or demand avoidance (e.g., Boksem & Tops, 2008; Giacomantionio et al., 2019; Roskes et al., 2012). While some of these researchers acknowledge this limitation, highlighting the methodological challenges of not directly assessing participants' motivation

to save energy (e.g., Giacomantonio et al., 2019), others solely rely on non-validated self-report measures (e.g., Muraven et al., 2006), which may not adequately capture the nuanced nature of energy conservation motivation. This underscores the necessity for a valid and reliable measure to assess individuals' momentary motivation to conserve energy.

Recognizing these limitations, we developed the Conservation of Human Energy Resources Index (CHERI), a state measure to assess individual's momentary motivation to conserve the energy they perceive to have available to them in each situation. Across four studies, our objective was to investigate the factorial structure and psychometric properties of the CHERI, in particular its reliability and validity. Additionally, we sought to establish empirical support for its cross-cultural equivalence among both German and English-speaking populations, with a specific focus on its applicability in psychological research.

### *Motivation, Effort, Human Energy, and Energy Conservation*

According to Van Iddekinge et al. (2023) effort is a behavior that stems from motivation. Specifically, work motivation serves as the psychological arousal, guiding and shaping work behavior by influencing employees' decisions about tasks, effort levels, and persistence. Yet, external factors can sometimes prevent motivation from translating into action, making motivation necessary but not always sufficient for effort. Likewise, while effort is crucial for performance, it does not automatically ensure efficient or effective behavior, for example when invested in the wrong places. Drawing on this reasoning, Van Iddekinge et al. (2023, p.129) propose an integrated definition of work effort, where effort is characterized as "how hard workers try to perform their jobs, which includes where they devote their effort (direction), the amount of their effort (intensity), and how long they persevere in their effort (persistence)". From a bio-physical perspective it is evident that individuals who exert themselves more intensely and for longer durations must expend a greater amount of energy in the process, thus tightly intertwining effort and human energy.

According to Quinn et al. (2012), human physical energy can be understood as the capacity of individuals to do work, to expend effort, and sustain activity. This includes both intentional actions such as communicating, thinking, or moving as well as unintentional automatic processes that maintain our vital bodily functions (e.g., breathing). Individuals draw the physical energy they need from energy resources stored within the body's cells, primarily in the form of glucose and adenosine triphosphate (ATP)[1]. When individuals seek to conserve physical energy, we assume that they reduce the frequency, intensity, or duration in what Quinn and colleagues call intentional expenditures, thereby reducing the organism's overall ATP consumption. It is noteworthy that, although the physical energy a person possesses may be conserved—for example by avoiding physical exertion or reducing cognitive strain (c.f. Muraven et al., 2006)—the body's actual physical energy levels (i.e., required for metabolic purposes) are neither reliably measurable through self-reports nor does it necessarily correspond to the actual effort individuals invest into a task (Quinn et al., 2012). Even when someone is tired and lacks energy, they may still be able to push themselves a little further. Conversely, despite having ample potential energy, some may choose not to invest significant effort if the perceived value of the outcome is considered too low. This leads us to the second type of energy, energetic activation, which refers to the subjective experience of feeling energized. This type of psychological energy, in contrast to physical human energy, is reliably and validly measurable with self-reports (e.g., Weigelt et al., 2022). Energetic activation can express itself in positive emotions, moods, or dispositions including feelings of vitality, vigor, or enthusiasm (Quinn et al., 2012). While this type of subjective experienced energy may serve as a valuable resource that fuels effortful behavior —such as

[1] "Adenosine triphosphate (ATP) is the source of energy for use and storage at the cellular level. ATP is consumed for energy in processes including muscle contraction, nerve impulse propagation, and chemical synthesis. The brain is the highest consumer of ATP in the body, consuming approximately twenty-five percent of the total energy available." (Dunn & Grider, 2023)

during periods of high-activation forms of positive affect, where individuals typically invest more effort (i.e. physical energy) in their activities and sustain this effort for longer durations (Quinn et al., 2012)—it appears evident, that this form of energy cannot be deliberately conserved in a manner similar to physical energy.

### *The Present Research*

To measure people's momentary motivation to conserve their energy, we developed a six-item state scale in German (CHERI-G), based on Quinn et al.'s (2012) understanding of human energy. In Study 1, we evaluated the CHERI-G's factorial structure by exploratory factor analysis (EFA) and its reliability. Additionally, we assessed the relationship between the CHERI-G and individual's energetic activation as part of the initial validation process. In Study 2, our objectives were to confirm the factorial structure of the CHERI-G through confirmatory factor analysis (CFA) and to assess the CHERI-G's validity by examining significant associations with effort-related measures. In Study 3, we evaluated the responsiveness and criterion validity of the CHERI-G, employing a two-wave study design. In Study 4, we developed an English adaptation of the scale, the CHERI-E. Subsequently, we examined its factorial structure, assessed its measurement invariance in comparison to the CHERI-G, and explored its associations with a variety of work-related validation criteria.

### *Development of the Measures*

The CHERI-G items were generated within the framework of a cyclical expert exchange. First, the three authors of the present study worked out a set of nine items based on the terminology of constructs that appear in the nomological network (e.g., Cronbach & Meehl, 1955) of human energies, for example physical energy (Quinn et al., 2012), energetic activation (Weigelt et al., 2022), vitality (Ryan & Frederick, 1997), and willpower (Job et al., 2010). The items were thoughtfully formulated to avoid any references to motives. For example, a valid strategy might be for a person to conserve their energy in anticipation of

future demands or in preparation for future losses (Muraven et al., 2006). However, to ensure a wider range of applicability, formulations such as "I want to conserve my strength for important future tasks" were succinctly revised to “Right now, I want to conserve my strength”[2].

In the subsequent phase, we conducted a face validity assessment. During this process, we made the decision to remove three problematic items (e.g., “I need to refuel my depleted energy”) that were originally derived from the ITW-M (Job et al., 2010). While it may seem reasonable that individuals want to restore a desirable energetic state after having exerted themselves (c.f. Giacomantonio et al., 2019), we chose to exclude these broader dimensions. This decision is made to avoid diluting the core concept of conserving energy resources. Furthermore, the desire of a person to restore their energy resources implies that they have previously exerted effort, as observed in constructs such as the need for recovery (NFR; van Veldhoven & Broersen, 2003). However, it is essential to note that the CHERI-G is designed to be versatile, applicable (1) for individuals who have depleted their energy and wish to conserve what remains, as well as (2) for those who are still in possession of their initial capacities and aim to sustain this advantageous state.

With the remaining six items we proceeded to evaluate semantic aspects. During our assessment, we noticed that the items featured adjectives like “mental”, “psychic”, or “cognitive” energy, suggesting the existence of diverse and distinct forms of energy resources. Following the recommendations provided by Quinn and colleagues (2012), we opted to remove these ambiguous everyday terms as they could be encompassed within the

[2] Notable, in this context the term “strength” is not exclusively associated with physical effort or muscular strength as suggested by the definitions of the Cambridge Dictionary (Cambridge University Press, n.d.) and the Oxford English Dictionary (Oxford University Press, n.d.). While the Cambridge Dictionary defines strength as “the ability to do things that need a lot of physical or mental effort”, the Oxford English Dictionary (Oxford University Press, n.d.) describes strength as “power or resilience, whether physical, mental, or due to the possession of resources”.

umbrella construct of “energetic activation”. Strictly speaking and from a theoretical point of view, the term “physical energy” describes both intentional biophysical and deliberate cognitive processes. However, in everyday language, physical energy is often associated solely with the use of muscular strength or movement-related activities. To prevent unnecessary confusion, only the terms “energy” and “strength” were used in the final version of the scale. At the end of the generation process, six concise items (see Table 1) emerged.

For the English adaption of the CHERI-G, we adhered to established cross-cultural adaptation guidelines by Beaton et al. (2000). This process was conducted twice, once using traditional human translation services, and once employing computer-assisted translation. For the latter we used OpenAI’s GPT-4 (OpenAI, 2023), an advanced language processing model founded on deep learning techniques, and DeepL-Pro Translator (DeepL, 2021), which employs artificial neural networks to translate texts. Both approaches yielded nearly identical versions, differing in only one item out of the five, and this discrepancy was solely on a stylistic level, not affecting the content. The supplementary Note SN1 provides a more detailed description of the entire translation process. The final form of the scale, referred to as the English version of the Conservation of Human Energies Index “CHERI-E”, is shown in Table 4.

## Study 1

In Study 1, we pursued two main objectives. Firstly, we investigated the CHERI-G's factorial structure using EFA and assessed its psychometric properties. Secondly, as part of the initial validation process, we investigated the relationship between the CHERI-G and individual's energetic activation. We expected energetic activation to be negatively associated with the motivation to conserve energy as individuals in states of high activation are inclined to exert greater levels of effort (Quinn et al., 2012). Individuals who experience high levels of energetic activation should therefore feel a relatively low need to conserve their resources.

### *Method*

#### *Ethical Requirements and Open Science*

Ethical approval (identifier #2019-05-00005) was obtained from the Ethics Commission of the Faculty of Human Sciences, University of Bern for all four studies. The raw data supporting the findings of Study 1 is available at https://researchbox.org/1877. All participants provided informed consent and engaged in the research voluntarily, without any incentives or rewards. Ethical standards were consistently maintained throughout the entire research project.

#### *Participants and Procedure*

Data was collected online using Unipark software. Participants were given access to the survey via a link or QR code. The initial sample included $N = 327$ university students from different universities in Switzerland. Six participants were excluded from the study because they had less than ten years of proficiency in German as a second language, resulting in a final sample size of $N = 321$ (73.2% female; $M_{age} = 24.84$ years, $SD = 5.41$). Over half of the sample (51.1%) engaged in part-time work while pursuing their studies. Following this, they proceeded to complete the questionnaire, with each measure presented on a separate page.

The questionnaire also included questions about personal information such as age, gender, language skills, field of study, and professional activities. Upon completion of the survey, participants were debriefed and thanked for their participation.

### *Measures*

In Study 1, we only used measures mentioned in the following[3].

*Motivation to Conserve Energy.* Motivation to conserve energy was measured using the six remaining items from our scale development process. The instruction of the CHERI-G states "How are you feeling at the moment?" Participants are asked to respond to this question by assessing their agreement with the six CHERI-G items (e.g., "Right now, I want to use as little of my energy as possible") on a six-point scale from 1 (*not at all true*) to 6 (*completely true*). Participants took a median of 33 seconds to complete the CHERI-G.

*Energetic Activation.* Energetic activation was measured with a one item pictorial scale of human energy (Weigelt et al., 2022) ranging from 1 (*depleted*) to 7 (*full of energy*). Each number on the scale was represented by a battery icon, visually depicting the corresponding state of charge (e.g., 1 = battery icon with empty charge, 7 = battery icon with full charge).

### *Data Analysis Strategy*

EFA was conducted based on both Field's (2018) and Osborne's (2014) guidelines. The analyses were performed in the following sequence: Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity, test of multicollinearity, parallel-analysis, Velicer's (2000) revised Minimum Average Partial (MAP) test, factor analysis, reliability analysis (internal consistency).

[3] Two of the original measures were excluded because they were collected by students as part of their master's theses.

Both, the KMO and the Bartlett's test are measures that indicate if the data is suitable for factor analysis. According to Field (2018, p.1014), a KMO value "close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors". To ensure the adequacy of the data for factor analysis, a minimum KMO value of 0.5 is required. The Bartlett's test indicates whether correlations are large enough for factor analysis. If the test statistic is significant "then it means that the correlations between variables are (overall) significantly different from zero" (Field, 2018, p.1015).

Also, extreme multicollinearity can pose significant challenges in factor analysis as it hinders the determination of the "unique contribution to a factor of the variables that are highly correlated" (Field, 2018, p.1015). As proposed by the author, we applied two approaches to identify multicollinearity. Firstly, we evaluated the determinant |R| of the R-matrix. If $|R| > 10^{-5}$, it suggests the absence of multicollinearity. Secondly, we examined the correlation matrix for variables exhibiting high correlations ($r > .80$), and if found, considered removing one of the variables.

As recommended by Velicer and colleagues (2000), we employed a combination of MAP and parallel analysis to determine the number of factors to extract. As for parallel analysis, we compared the observed eigenvalues from the raw data to those from the randomly generated data and only retained factors with eigenvalues above the 95$^{th}$ percentile (c.f. Osborne, 2014). Regarding the MAP criteria, we retained the number of factors based on "the point where the average squared partial correlation reaches a minimum" (Velicer et al., 2000, p.54). The MAP test and parallel analysis were carried out using O'Connor's (2000) SPSS syntax.

For factor analysis we chose principal axis factor analysis (PAF) as it is less sensitive to violations of multivariate normality assumption compared to other methods such as maximum likelihood (Costello & Osborne, 2005). Indeed, visual inspection of the chi-square plot of squared Mahalanobis distances (c.f. Burdenski, 2000; Ramzan et al., 2013) and the

results of the Henze-Zirkler test (HZ = 3.00, $p < .001$) as recommended by Mecklin and Mundfrom (2005) showed that the data did not follow a multivariate normal distribution.

## *Results and Discussion*

### *Factor Structure of the CHERI-G*

The KMO of 0.90 is considered "marvellous" and the Bartlett's test of sphericity was significant (approx. $\chi^2 = 1254$, $p < .001$). Both results indicate that our data were adequate for factor analysis (Beavers et al., 2013; Field, 2018). There was no evidence of extreme multicollinearity, as none of the bivariate correlations in the correlation matrix exceeded a value of $r = .80$. Moreover, the determinant of the R-matrix ($|R| = .019$) exceeded $10^{-5}$. Subsequently, parallel analysis was applied to determine the number of factors. The results revealed a one-factor solution which was further confirmed by the MAP criteria and by plotting the results of the parallel analysis. PAF indicated that the extracted single factor explained a total of 70.11 % of the variance of the CHERI-G. According to Comrey and Lee (1992) loadings of $\lambda > 0.71$ are considered excellent. As Table 1 shows, all six items loaded excellent [.74 – .86] on the extracted factor. In conclusion, the CHERI-G seems to measure a one-dimensional construct.

### *Descriptive Statistics and Reliability*

Means and standard deviations for the six CHERI-G items and the total scale are shown in Table 1. In the right-hand column, corrected item-total correlations are displayed. Since all $r_{it}$s exceed the threshold of .50 by far, it can be concluded that the items reflect substantial amounts of information (c.f. Penfield, 2013). The average inter-item correlation of .64 indicates that the CHERI-G measures a homogeneous construct (c.f. Briggs & Cheek, 1986). Regarding reliability, the scale showed excellent internal consistency (McDonald's $\omega = .95$). Without detracting from our remarkable findings, we would like to point out that the above-

mentioned statistical parameters may also signal redundancy among the items due to their considerable magnitude (c.f. Briggs & Cheek, 1986; DeVellis, 2017; Penfield, 2013; Streiner, 2003). Therefore, in a second study, we should take a closer look at where parsimony might be achieved through meaningful shortenings of the scale.

### *Validity of the CHERI-G*

In terms of construct validity, factor analysis showed that the observed variables converge and loaded highly onto the same underlying factor. As predicted, CHERI-G scores were negatively correlated with energetic activation ($M = 2.84$, $SD = 0.91$), $r = –.44$, $p < .001$, two-tailed testing (95% CI [−.53, −.35]; bias-corrected and accelerated bootstrapping with 5,000 resamples). The substantial negative correlation between the two variables suggests that energetic individuals are less motivated to conserve their energy. This may be attributed to their subjective perception of having sufficient energy reserves at their disposal. In contrast, individuals who feel drained of energy might be more motivated to conserve their remaining resources, for example to prevent themselves from becoming completely exhausted and being unable to respond to urgent demands (Gendolla & Richter, 2010).

## **Study 2**

In Study 2, we sought to verify the CHERI-G's factorial structure by applying CFA. An additional objective was to investigate the validity of the new state measure CHERI-G by examining whether it is significantly associated to six effort-related measures, including hope for success (e.g., approach motivation) and fear of failure (e.g., avoidance motivation), motivation for cognitive effort, subjective vitality, implicit theories of willpower, and energetic activation.

First, we expected the CHERI-G to be negatively related to hope for success and positively to fear of failure. Approach-motivated individuals are oriented towards possible success whereas avoidance-motivated individuals are more concerned with preventing failure

(Elliot & Harackiewicz, 1996). Since achievement requires effort, people high in hope of success might rather be motivated to invest their energy resources than conserving them in their goal attainment process. As for fear of failure, Roskes et al. (2012) found evidence in a series of studies with creativity tasks that avoidance-motivated people use their efforts and resources selectively. Building upon this finding, we propose that individuals with a higher motivation to avoid failure will exhibit a stronger motivation to conserve their energy resources.

Second, we assumed the CHERI-G to be negatively correlated to the cognitive effort someone would currently be willing to make as measured with the motivation for cognitive effort scale (MFC; Blaise et al., 2021). People that are highly intrinsically motivated to exert cognitive effort should not be motivated to conserve their energy resources, since effort, regardless of its nature, requires energy investment.

Third, we assumed a negative association between subjective vitality and the motivation to conserve energy resources. Subjective vitality embodies a positive sensation of aliveness and energy (Ryan & Frederick, 1997). It describes the inherent energy within an individual that can be used or managed for intentional actions (Ryan & Deci, 2008). Consequently, subjective vitality is robustly associated with behavioral outcomes. To illustrate, when in vital states, people are more active and productive. As a result, those who experience a strong sense of vitality tend to use their energy resources for productive purposes, leading to higher energy consumption and less conservation. The contrary may apply for people low in vitality.

Fourth, we expected implicit theories of willpower to be negatively related to the motivation to conserve energy resources. In the context of self-regulation, Job et al. (2010) developed a scale to address people's implicit theories of willpower for strenuous mental activities (ITW-M). On the one hand, individuals with high ITW-M scores tend to believe that their willpower is an unlimited resource and accordingly perform better in situations where

self-regulation is required. Individuals with low ITW-M scores, on the other hand, hold to a theory that willpower is exhaustible. In a situation where self-control is needed, they would act congruent with their beliefs and, therefore, be prone to feel depletion. Regarding our newly developed CHERI-G, participants who hold strong beliefs about unlimited willpower may not perceive a necessity to conserve their mental energy resources, which are encompassed within Quinn et al.'s (2012) broader concept of physical energy. According to their perspective, mental energy such as willpower is considered inexhaustible and non-depletable (Job et al., 2010). The opposite should be true for people with limited-resources theories. Thus, we expect our scale to be correlated negatively with the ITW-M.

Fifth, in an attempt to replicate the findings from Study 1, we expected a negative association between energetic arousal and the CHERI-G.

## *Method*

### *Ethical Requirements and Open Science*

Ethical approval was once again granted by the human research ethics committee of the University of Bern. The raw data supporting the findings of Study 2 is available at https://researchbox.org/1877. Each participant provided informed consent and engaged in the research voluntarily.

### *Participants and Procedure*

As in Study 1, we recruited students from different universities in Switzerland directly on campus and online. The initial unadjusted sample included $N = 616$ participants. Given that the survey was conducted online, we implemented a seriousness check as recommended by Aust et al. (2013). This step was undertaken to ensure the integrity of our data, and to minimize potential biases in our sample. For this purpose, we asked participants whether they had taken part seriously or just had clicked through and wished their data to be discarded.

Based on this, six people were removed them from the final sample. In addition, as we conducted the validation process to assess effort-related variables (e.g., achievement motivation) and energetic states (e.g., vitality), it was imperative for us to adhere to a homogenous population. Therefore, we excluded $n = 32$ participants who indicated that they were not students. Also, during data preparation we detected extreme outliers from two participants as their total values from the hope for success scale exceeded the critical *z*-value of ±3.29 (c.f. Tabachnick & Fidell, 2019). The final sample after adjustment was $N = 576$, (73.2 % female; $M_{age} = 23.16$, $SD = 3.73$). Of all participants, 39.8% were working part-time alongside their studies. The reported findings remain consistent when conducting the analyses using the unadjusted sample.

*Measures*

In the following, we report all measures that we applied. In our survey, we administered the measures online using the Unipark computer software. Each measure was displayed on a separate page, with the order of appearance randomized by the software, except for the demographic data questions and the seriousness-check, which were presented at the end. Internal consistencies (McDonald's ω) and descriptive statistics for these measures are presented in Table 2.

*Motivation for Cognition.* State cognitive motivation was measured with the Motivation for Cognitive Effort scale (Blaise et al., 2021). Participants indicated their momentarily motivation for cognition on each of the ten items (e.g., "Right now, I would like to solve a puzzle") on a seven-point Likert-type scale from 1 (*does not apply at all*) to 7 (*applies exactly*). Participants responded to these items as they applied in the present moment.

*Hope of Success and Fear of Failure.* To measure approach and avoidance motivation on a dispositional level, we administered the revised brief Achievement Motives Scale (AMS-R)

for German-speaking samples (Lang & Fries, 2006). Approach motivation was assessed with five hope of success items (e.g., "I like situations, in which I can find out how capable I am") whereas avoidance motivation was measured with five fear of failure items (e.g., "I feel uneasy to do something if I am not sure of succeeding"). Answers were given on a four-point scale from 1 (*not true at all*) to 4 (*absolutely true*).

*Subjective Vitality.* To measure subjective vitality, we used the German state version of the Subjective Vitality Scale (SVS-G; Bertrams et al., 2020). Participants assessed their agreement with each of the five items (e.g., "I feel energized right now.") on a seven-point Likert-type scale from 1 (*does not apply at all*) to 7 (*applies exactly*).

*Implicit Theories About Willpower.* The Implicit Theories About Willpower for Strenuous Mental Activities Scale (ITW-M; Job et al., 2010) was employed. Participants were asked to indicate how much they agreed or disagreed with each of the six items (e.g., "After a strenuous mental activity, I feel energized for further challenging activities") on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The higher the scores the stronger the inclination towards a belief that mental resources are unlimited.

*Energetic Activation and Motivation to Conserve Energy.* To measure energetic activation and motivation to conserve energy, we used the same measures as in Study 1.

### *Data Analysis Strategy*

We sought to verify the CHERI-G's one-dimensional factor structure found in Study 1 using CFA. We analyzed the data with R's lavaan package (Rosseel, 2012). CFA was performed using Satorra-Bentler mean adjusted maximum likelihood (MLM) estimation method. Because we had already obtained hints of redundancy in our six-item scale in Study 1, we were particularly interested in potential covariances between error terms of similarly worded items (e.g., Brown, 2015). Therefore, we consulted modification indices to identify and

improve model fit, but only as long as theoretically sound rationales could be established. When evaluating correlated residual errors, we considered the magnitude and significance-level of the correlation, the theoretical justification for the correlation, and the impact of the correlation on the overall model fit and parameter estimates. Cut-off values for acceptable model fit were chosen based on the recommendations of Hooper et al. (2008). According to the authors, the fit indices should meet the following criteria: the root mean square error of approximation (RMSEA) should be ≤ 0.08, the comparative fit index (CFI) and the Tucker-Lewis index (TLI) should be ≥ 0.95, and the standardized root mean square residual (SRMR) should be ≤ 0.08. After obtaining fit indices, we performed a scaled chi-square difference test (Satorra & Bentler, 2001) to compare the goodness-of-fit of nested models in order to see whether the non-restricted model fit the data significantly better than restricted one.

To provide further evidence for the validity of the CHERI-G, we calculated bivariate correlations (Pearson's r coefficient) to examine its relationship with the six validation criteria listed above. To address potential alpha-error-inflation in the six primary analyses involving the CHERI-G, we applied a Bonferroni correction, setting the threshold for statistical significance at $p$ = .05 / 6 tests = .008 (two-tailed).

## *Results and Discussion*

### *Preliminary Analysis and Descriptive Statistics*

The Mardia test (Korkmaz et al., 2014) indicated that the assumption of multivariate normality was not met as shown by Mardia's coefficients of skewness ($\hat{\gamma}_{1,p}$= 399.1, $p$ < .001) and kurtosis ($\hat{\gamma}_{2,p}$= 28.3, $p$ < .001). Under these circumstances, maximum likelihood estimation may yield biased standard errors (Muthén & Kaplan, 1985). Hence, we opted for the MLM estimator, known for its robustness to multivariate normality, offering both adjusted standard errors and a mean-corrected "Satorra-Bentler scaled" test statistic. Table S1 in the supplemental material displays the results of the item analysis, which include mean scores,

standard deviations, skewness, and kurtosis.

*Confirmatory Factor Analysis*

We estimated three CFA models (M1–M3; see Table 3). The first model (M1) showed good fit for all fit indices except for RMSEA = 0.096. Modification indices suggested a correlation between the error terms of the CHERI-G items 5 and 6, which was not very surprising as their wordings are very similar (item 5 "invest as little energy as possible" vs. item 6 "use as little of my energy as possible"). Therefore, we tested a model respecting the error correlation of items 5 and 6 (M2) as well as a model in which the item 6 was omitted (M3). Upon reviewing the standardized coefficients for items 5 and 6, we chose to exclude item 6 from our analysis, while retaining item 5. This decision was based on the significantly higher standardized factor loading of .88 for item 5 compared to .70 for item 6. Overall, the 5-items solution (M3) yielded the best model fit indices (RMSEA = 0.076, CFI = 0.99, TLI = 0.98, and SRMR = 0.016) and showed a slightly better internal consistency (Cronbach's $\alpha$ = .94) than the six-item solution (Cronbach's $\alpha$ = .93). The graphical illustrations of the estimated models including their standardized estimates can be found in Figure SF1 in the supplemental material.

*Validity of the CHERI-G*

Table 2 presents the descriptive statistics, internal consistencies ($\omega$) and intercorrelations for the measures analyzed in Study 2, with confidence intervals calculated using bias-corrected and accelerated bootstrapping with 5,000 resamples. Results demonstrate significant correlations between the five-item CHERI-G score and all validity criteria in the expected direction as hypothesized[4]. As all relationships were theoretically predefined, the observed

[4] Considering the substantial variance in energy levels within days (e.g., Hülsheger, 2016; Kosenkranius et al., 2023), we reanalyzed our results while considering time-of-day effects. Our

statistically significant bivariate correlations provide compelling evidence for the validity of the CHERI-G. The strongest correlations can be found between the CHERI-G score and the two variables related to the broader concept of human energy, vitality ($r = –.51$, $p < .001$) and energetic activation ($r = –.46$, $p < .001$). These findings align with the nomological network theory proposed by Cronbach and Meehl (1955), which suggests that constructs within the same network should exhibit meaningful relationships. The statistically significant high correlations indicate that both variables are conceptually related to the CHERI-G while remaining distinct enough to be considered separate constructs (c.f. Cheung & Wang, 2017). Additionally, our analysis revealed a substantial correlation ($r = –.38$, $p < .001$) between the CHERI-G and motivation for cognitive effort (MFC). Importantly, MFC has shown to be a reliable predictor of individuals' willingness to engage in mentally challenging tasks (Blaise et al., 2021). This outcome provides further support for the CHERI-G's association with motivational variables within the domain of cognitive effort investment. Moreover, *distal trait* variables (e.g., approach/avoidance motivation and implicit theories about willpower) exhibit weaker associations ($r = |.15|$ to $|.24|$) with the CHERI than *proximal state* correlates ($r = |.38|$ to $|.51|$). This finding is not surprising, as the CHERI-G is functioning at the same level of analysis as the administered state measures, providing additional support for the validity and state nature of the scale.

findings remained robust, with all observed changes in the validation coefficients limited to at most one unit in the second decimal place.

## Study 3

The main goal of Study 3 was to establish evidence for the inherent state nature of the "CHERI-G" within a specific work environment. To achieve this goal, we carried out a pre-registered two-wave study in which we asked teachers to evaluate their motivation to conserve energy before and after their teaching sessions. We expected that teachers' motivation to conserve their energy would significantly increase after teaching compared to teacher's motivation before teaching. Additionally, as a measure of criterion validity, we assumed that mental effort exerted during teaching would positively predict energy conservation motivation after teaching, even after controlling for CHERI-G assessed before teaching.

### *Method*

#### *Ethical Requirements and Open Science*

Ethical approval and informed consent were obtained the same way as in the previous studies. Study 3 was pre-registered before the data collection with AsPredicted.org (https://aspredicted.org/i3bd9.pdf – identifier #149205). The raw data of this study is available at https://researchbox.org/1877.

#### *Participants and Procedure*

We calculated the sample size necessary to detect a medium-sized effect (Cohen, 1988) with sufficient statistical power using G*Power 3.1 (Faul et al., 2009) for our within-subjects design. The input parameters (paired *t*-test, $\alpha = .05$, two-tailed testing, $d_z = 0.5$, 1-ß = .99) resulted in a minimum sample size of $N = 76$. The study was accessed by $N = 411$ teachers before their lessons and by $N = 329$ teachers after their lessons. Data matching was performed using the personal identifiers that participants generated at both measurement times. As pre-registered, we only analyzed the data of participants who taught more than one lesson on that

day and provided complete data for the central variables at both measurement times, resulting in a final sample size of $N = 325$ teachers. No extreme outliers were identified. Participants were teachers (80% female, $M_{age} = 38.91$, $SD = 11.66$) Switzerland across numerous grade levels, ranging from kindergarten to high school. On average, the teachers had 13.46 years of teaching experience ($SD = 11.02$), held an employment rate of 76.49% weekly workload ($SD = 28.57$), and taught 4.33 lessons ($SD = 1.16$) in class sizes of $N = 18$ students ($SD = 4.69$) on the day of the survey.

After providing informed consent teachers completed the first questionnaire in the morning just before teaching and the second one after teaching. Responses were given either online using a smartphone or by using a paper-pencil format. In both versions, all the measures were presented on a single page in the exact same order, with the CHERI-G measure being displayed at the beginning. Paper-pencil questionnaires were administered in separate envelopes to prevent potential interference in the assessment of the variables between pre and post measures. At the conclusion of the second survey, participants provided demographic information. Teachers did not receive any compensation.

### *Measures*

*Motivation to conserve energy.* We employed the 5-item version of the CHERI-G. The scale showed excellent internal consistency at the first (McDonald's $\omega = .96$ ) and second time of measurement (McDonald's $\omega = .98$).

*Mental Effort During Teaching.* Teachers rated the mental effort required for teaching using the 20-point mental effort item from the NASA-TLX (Hart & Staveland, 1988), with response options ranging from 1 (*very low*) to 20 (*very high*).

*Data Analysis Strategy*

We conducted a paired t-test to evaluate the internal responsiveness of the CHERI-G (c.f. Husted et al., 2000). Specifically, we examined the within-person differences in energy conservation motivation before and after teaching. To assess the impact of mental effort exerted during teaching on energy conservation motivation, a multiple linear regression was performed with CHERI-G mean scores after teaching as dependent variable and mental effort, as measured using the NASA-TLX, as the predictor variable. Additionally, CHERI-G mean scores before teaching were included as a covariate.

## *Results and Discussion*

In line with our hypothesis, the results of the paired *t*-test ($t[324] = -10.57$, $p < .001$, two-sided, $d_z = -0.47$) revealed, that teachers' motivation to conserve energy was significantly lower before teaching ($M = 3.28$, $SD = 1.30$) than after teaching ($M = 4.02$ , $SD = 1.42$). The found increase in teachers' motivation to conserve energy over time underscores the CHERI-G's responsiveness (c.f. Husted et al., 2000) and the *state* nature of the underlying construct.

A secondary preregistered analysis was carried out to provide insight into whether the mental effort exerted by teachers during the lesson predicts their post-teaching energy conservation motivation while controlling for their baseline values before the lesson. Both the overall model ($F[2,322] = 155.56$, $p < .001$, $R^2_{adj} = 0.49$) and the effect of mental effort on energy conservation were significant ($b = 0.09$, $SE_b = 0.02$, $\beta = .20$, $p < .001$, 95 % bootstrapped CI [.10, .29]). This result provides evidence for the criterion validity of the CHERI-G, as exerted mental effort at work successfully predicted energy conservation after work. These results suggest that the more time teachers spent teaching in the classroom, the higher their motivation to conserve energy was by the end of the day[5].

[5] All results remained consistent when excluding the data of participants who completed the questionnaires carelessly. This included instances such as completing the before and after

**Study 4**

The primary aim of Study 4 was to validate the CHERI using work-related validation criteria. This preregistered study encompassed four main steps: (1) translating the CHERI from German to English, (2) assessing whether the one-factorial structure observed in the German version also applies to the English version (CHERI-E) as well, (3) demonstrating cross-cultural equivalence, and (4) collecting additional evidence for the validity of the CHERI-E. For the latter, we examined the CHERI-E's associations with five work-related measures: proactive vitality management, energy management strategies, vigor, need for recovery, and emotional exhaustion.

First, we expected the CHERI-E to be positively correlated to emotional exhaustion, a key aspect of the burnout syndrome (Maslach & Jackson, 1981; Maslach et al., 2001). The authors note that people with depleted emotional resources typically experience a loss of energy, which impairs their ability for mental exertion. Hence, we posited that a stronger state of emotional exhaustion should be associated with an increased motivation to conserve energy reserves.

Second, we hypothesized a positive correlation between the CHERI-E and the need for recovery (NFR). NFR refers to the degree to which an individual requires recuperation from work-induced efforts. It is described by "temporary feelings of overload, irritability, social withdrawal, lack of energy for new effort, and reduced performance" (van Veldhoven & Broersen, 2003, p. 3). Efficient recovery is most likely to be successful when reducing energy expenditure. Consequently, a stronger need for recovery should be linked to a higher motivation to conserve energy.

Third, work-related vigor should be negatively associated to the CHERI-E. Schaufeli et al. (2006, p. 702) define vigor as marked by "high levels of energy and mental resilience

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measurements on two different days of the week, at improbable teaching times, or with a time gap between measurements shorter than ninety minutes (e.g., two lessons).

while working, the willingness to invest effort in one's work, and persistence even in the face of difficulties". As shown in Study 1 of this research which revealed a negative correlation between energy conservation and subjective vitality (i.e., a concept frequently used synonymously with vigor; c.f. Quinn et al., 2012), we expect a similar relationship between work-related vigor and the CHERI-E.

Fourth, we investigated the relationship between the CHERI-E, energy management strategies (EMS), and proactive vitality management (PVM). EMS have received significant attention within workplace contexts, often in relation to factors like job satisfaction and subjective vitality or vigor (e.g., Fritz et al., 2011; de Bloom et al., 2015; Parker et al., 2017; Zacher et al., 2014). Building on this, PVM refers to goal-oriented strategies adopted by individuals to actively manage their physical and mental energy based on their individual needs and preferences (Op den Kamp et al., 2018). As the associations between these two constructs and the CHERI-E are conceivable in either direction, no prediction was made in advance. For instance, on one hand, individuals who utilize EMS might have a strong need to preserve their energy. On the other hand, those who employ EMS effectively could also be those who have accumulated an abundance of energy and do not consider it necessary to use their reserves sparingly. An analogous perspective could be conceivable in the case of proactive vitality management.

## *Method*

### *Ethical Requirements and Open Science*

We obtained ethical approval and informed consent in the same way as for our previous studies. Study 4 was pre-registered at AsPredicted.org (https://aspredicted.org/by9fk.pdf – identifier #151350) before collecting data. The raw data for this study can be accessed at https://researchbox.org/1877.

*Participants and Procedure*

A sample of $N = 606$ individuals working full-time jobs from the United Kingdom was recruited using the Prolific recruitment platform (https://www.prolific.co). They received £0.90 for their participation. As outlined in our preregistration, we excluded participants that lacked the necessary language skills for meaningful participation in the study ($n = 2$) or failed to the attention check criteria ($n = 12$) recommended by Meade and Craig (2012). The latter included participants who reported having responded carelessly ($n = 1$) and those displaying Mahalanobis distances with $p < .01$ on the six central variables ($n = 11$).

The final sample consisted of $N = 592$ participants (49.2% female, $M_{age} = 40.36$, $SD = 11.46$). On average, participants worked 39.44 hours ($SD = 5.70$) per week, had worked within their organization for 8.68 years ($SD = 9.32$), and had 13.21 years ($SD = 10.77$) of professional experience. The majority had a permanent working contract (90.9%). In terms of education, 26.2% had completed high school, 40.5% held an undergraduate degree, and 18.58% had attained a postgraduate degree. The participants represented diverse professions and industries, with the four most prominent sectors being education (14.7%), information technology (10.8%), healthcare and medical services (10.6%), as well as government and public administration (10.5%). The full report of the sample demographics can be found in the supplementary Table S2.

Upon providing informed consent, participants proceeded to answer the questionnaire, with each measure presented on a separate page. The CHERI-E was the initial measure presented, while all subsequent measures were displayed in a randomized order. At the end of the survey, participants were asked to provide demographic information. Additionally, we incorporated two quality checks. First, we asked participants, if they feel that they had the necessary language proficiency to contribute meaningfully to the study. Second, we followed Meade and Craig's (2012) recommendation by including a self-report measure, soliciting

participants' honest opinions about the use of their data in our analyses (i.e., an attention check).

*Measures*

In the following, we mention all measures that we applied. Internal consistencies (McDonald's ω) of all measures can be found in Table 6.

*Motivation to Conserve Energy.* We employed the English version of the 5-item CHERI. The median time to answer the five items was 20 seconds.

*Emotional Exhaustion.* Emotional exhaustion was assessed using a 9-item subscale of the Maslach Burnout Inventory (Maslach & Jackson, 1981). For each of the items (e.g., "I feel emotionally drained from my work") participants indicated how often they experienced these feelings throughout the year on a seven-point scale from 1 (*never*) to 7 (*every day*).

*Work-related Vigor.* To measure vigor, we employed the vigor subscale from the 9-item Utrecht Work Engagement Short Scale (UWES-9; Schaufeli et al., 2006). Participants indicated how often they experienced feelings of vigor at work on a seven-point scale ranging from 1 (*never*) to 7 (*always/every day*) (e.g., "At my work, I feel bursting with energy"). Higher scores indicated a higher frequency of experienced vigor at work throughout the year.

*Need for recovery*. Participants indicated the extent to which they need to recuperate from work on the NFR scale (Veldhoven & Broersen, 2003). For each of the 11 items, they indicated whether 1 (*yes*) or 0 (*no*) the statement (e.g., "I find it difficult to relax at the end of a working day") applied to them. For data analysis, a percentage was computed as a total score. For a participant responding "yes" to eight out of eleven statements, this would translate to a total score of 72.7.

*Energy Management Strategies.* We assessed the use of EMS with items taken from a list of 42 empirically investigated strategies by Fritz et al. (2011). We limited our selection to those strategies that have been shown to exhibit the strongest correlations with vitality (i.e., energy) and are frequently used in practice (c.f. de Bloom et al., 2015; Parker et al., 2017; Zacher et al., 2014). To compile a diverse range of strategies, we assessed participants' energy management behavior with six different micro-breaks six micro-breaks (three mental and three physical) as well as three work-related energy management strategies. The three mental micro-breaks comprised "meditating/doing relaxation exercises", "talking to someone about common interests like sports or hobbies", and "looking out the window". The three physical micro-breaks encompassed the three physical micro-breaks were "doing some form of physical activity, including walks or stretching", "going outside for some fresh air", and "having a snack". Lastly, the three work-related energy management strategies consisted of one prosocial strategy ("offering to help someone at work"), one organizational strategy ("setting a new goal"), and one meaning-related strategy ("focusing on what gives me joy"). For our analyses, the total score for micro-breaks was computed by averaging the scores of both the mental and physical mental micro-breaks. Similarly, the total score for work-related energy management strategies was calculated by averaging the scores of three respective items. Participants answered each of the statements by indicating on a scale from 1 (*never*) to 5 (*very often*) how frequently they used the respective EMS at work today. To account for participants who could not apply any strategies because they did not work on that day, we introduced an extra response option, "not applicable (I did not work today)". Responses falling into this category were considered missing values when computing the mean scores for both the micro-breaks and work-related EMS variables.

*Proactive Vitality Management.* We employed the PMV scale (Op den Kamp et al., 2018) to assess participants' strategies used "today at work" to manage their vitality. Participants replied to each of the eight statements (e.g., "Today, I made sure that I felt energetic during

my work") on a 7-point scale ranging from 1 (*totally disagree*) to 7 (*totally agree*). Again, a "not applicable (I did not work today)" category was included for participants who did not engage in work on the given day. For data analysis, values in this category were treated as missing.

*Data Analysis Strategy*

To investigate whether the one-factor structure identified in the German version (CHERI-G) can be extended to the English version (CHERI-E), we carried out a CFA employing the same software tools and model specifications as used in Study 2. This model was also used as a baseline to assess measurement invariance (MI) between the German and English versions of the CHERI.

To test MI, we conducted a multi-group confirmatory factor analysis (MGCFA) following the guidelines provided by Leitgöb et al. (2023) and the established conventions outlined by Putnick and Bornstein (2016). In this analysis, we examined MI at three different levels: configural, metric (weak), and scalar (strong) invariance. First, we tested for configural invariance to determine if the same factor structure was supported in both cultural groups. Next, we assessed if metric (weak) invariance was given, which implies that the factor loadings of the indicators measuring the latent variable are consistent across both groups. Lastly, we examined scalar (strong) invariance, by investigating whether the factor loadings and intercepts were equal across groups. We considered configural invariance to be given when the model measuring the latent construct fit the data in both groups with standardized factor loadings ideally exceeding 0.3–0.4. To test metric and scalar invariance, we compared each model fit with that of the next lower, less restricted measurement level. When we found no significant deterioration in fit ($\Delta CFI \leq 0.01$ and $\Delta RMSEA \leq 0.015$), we concluded that measurement invariance was supported by the data.

To further validate the CHERI-E, we calculated bivariate correlations (Pearson's r) between the CHERI-E and the five validation criteria mentioned above. We addressed alpha-

error-inflation in the five main analyses involving the CHERI-E by considering a Bonferroni corrected $p$ = .05 / 5 tests = 0.01 (two-tailed) as the threshold for statistical significance.

### *Results and Discussion*

We conducted a CFA to assess whether the one-factorial structure observed in the German version of the CHERI applies to the CHERI-E as well. The obtained fit indices indicate a reasonable overall fit (c.f. Hooper et al., 2008) and thus support the assumption of a one-dimensional structure of the scale: $\chi^2(5) = 16.65$, $p$ = .005, RMSEA = 0.063 (90% CI [0.039–0.088]), CFI = 0.995, TLI = 0.989, SRMR = 0.014. A detailed overview of the factorial structure, including standardized estimates of the factor loadings, can be found in the Figure SF2 in the supplemental material.

An MGCFA was employed to examine whether the CHERI-G and CHERI-E assess the construct of "energy conservation" in the same way across both German and English cultural contexts. Measurement invariance between the English worker sample ($N$ = 592) and the German student sample ($N$ = 576) was established across all three levels (i.e., configural, metric, and scalar). Each of the MI models proved adequate goodness-of-fit and showed no significant deterioration in fit ($\Delta$CFI $\leq$ 0.01 and $\Delta$RMSEA $\leq$ 0.015) when compared to the less restricted model (see Table 5). As MI has been established across both cultural (German vs. English) and social (workplace vs. academia) contexts, we concluded that the CHERI can be confidently used in different settings and populations without significant information loss, thereby enhancing its practical applicability and validity.

In terms of validity, our findings reveal significant correlations between the CHERI-E and four the validity criteria — all in the predicted direction (see Table 6)[6]. Particularly, the

[6] As a robustness check, we replicated the correlation analyses, accounting for within-day variance in energy levels (e.g., Hülsheger, 2016; Kosenkranius et al., 2023), following the procedure employed in Study 2. Our reported findings remained unchanged, with validation coefficients showing minimal alterations, typically within the fourth decimal place.

measures of "need for recovery" ($r = .44$, $p < .001$) and "emotional exhaustion" ($r = .40$, $p < .001$) exhibit the most substantial relationships with the CHERI-E. These associations provide strong evidence of their conceptual proximity to the CHERI-E, yet they maintain enough distinctiveness to be considered separate constructs (c.f. Cheung & Wang, 2017). We conclude that the motivation to conserve energy is strongly related to energy losses and might implicitly be accompanied by a need to restore energy reserves. However, it is also conceivable that individuals who have no need to regenerate will nevertheless want to save their energy for specific purposes or reasons (e.g. saving up for important upcoming tasks). Moreover, we found a negative association for proactive vitality management ($r = –.17$, $p < .001$), suggesting that conserving energy is clearly distinct from managing vitality. As expected, work-related vigor exhibited a negative correlation with the CHERI-E ($r = –.27$, $p < .001$). Notably, this correlation was weaker than the one observed with general subjective vitality, as measured by the SVS-G in Study 2 ($r = –.51$, $p < .001$). One plausible explanation for this discrepancy may be the differing temporal proximities of the constructs assessed by the measures. While the SVS-G captures momentary feelings of subjective vitality in real-time (proximal to the timeframe of the CHERI), the UWES-9 retrospectively assesses participants' chronic levels of vigor over the course of a year (distal to the timeframe of the CHERI). Similar temporal considerations could possibly also account for the non-significant correlations we observed in relation to energy management strategies. It appears that occasionally stretching one's legs or having a snack during work may not be sufficient to establish a significant association with post-work energy conservation motivation. This could be attributed either to the type of strategies chosen for our study, particularly micro-breaks, which may not be suitable for regulating energy levels in the long term (e.g., Zacher et al., 2016), or to the low frequency of using energy management strategies, which does not always guarantee their effectiveness.

## General Discussion

The primary aim of the present research was to develop and validate a brief scale for assessing individuals' motivation to conserve their energy resources. To achieve this, we created two language versions of the Conservation of Human Energy Resources Index, one in German (CHERI-G) and the other in English (CHERI-E). First, both five-item CHERI versions effectively capture a unidimensional construct with reasonable goodness-of-fit and high internal consistency. Second, the state nature of the CHERI is underscored by its responsiveness, as we successfully demonstrated in a two-wave design. In this context, we were also able to provide sound evidence for the CHERI's criterion validity by showing its significant relationship with mental effort during teaching. Third, the CHERI's validity is well-supported by meaningful theoretical correlations with constructs in the broader nomological network of energy, effort, and motivation. Specifically, it demonstrates significant associations with variables such as emotional exhaustion (Maslach & Jackson, 1981), the need for recovery (van Veldhoven & Broersen, 2003), energetic activation (Weigelt et al., 2022), subjective vitality (Bertrams et al., 2020), and cognitive motivation (Blaise et al., 2021). Last, measurement invariance analyses revealed that equivalence for the construct of "energy conservation" was established across distinct cultures (German and English) and social contexts (workplace and academia) — allowing us to generalize the findings from all four of our studies to both versions of the scale.

With just five items and a median completion time of twenty seconds, the CHERI offers a practical and economic measure for assessing motivation in relation to effort and energy. This versatility makes it suitable for addressing a wide array of research questions in various research disciplines. Practical applications of the CHERI are conceivable, for example, in the field of recovery research (e.g., Fritz et al., 2013; Kühnel et al., 2017; Sianoja et al., 2016). As Sonnentag et al. (2022) noted, validated measures for assessing break experiences and energy-management strategies are currently lacking. Specifically, limited

research has investigated the role of breaks in replenishing energy resources (Demerouti et al., 2011). To address these gaps, we propose the implementation of the CHERI in this area of study. Understanding why and when individuals feel the need to conserve energy might be useful for informing new policies and guidelines for rest and breaks. The CHERI may be used in research aimed at identifying tasks or situations in the workplace that foster the need for energy conservation or in contrary enhance energy replenishment. This information could provide guidance for optimizing parameters related to breaks (e.g., frequency, type, duration, or timing) and tasks in the workplace, thereby enhancing overall well-being and work engagement (e.g., Kühnel et al., 2016; Zacher et al., 2014). Thus, the integration of the CHERI into recovery not only tackles the measurement challenges highlighted by Sonnentag et al. (2022) in assessing break experiences but also provides a novel lens for investigating them.

Moreover, employing the CHERI as a state measure in occupational settings can offer practical advantages in analyzing motivation-dependent performance indicators. For instance, organizations could explore the mediating role of energy conservation between structural workplace factors and employees' performance metrics. In a first step, assessing individuals' momentary motivation to conserve energy could yield valuable insights into how energy conservation relates to characteristics of the physical environment and job design. Regarding the physical environment, the CHERI helps to understand how individuals' motivation to conserve energy varies based on factors such as workplace layout, design, ergonomics, lighting, temperature, and noise levels. In terms of job design, the scale can provide information on how job roles, task distribution, task sequencing, and prioritization influence energy conservation motivation. In a second step, this information can be combined with productivity levels, task completion rates, the quality of work, and other performance metrics, to identify patterns and comprehend how variations in energy conservation motivation affect employee performance outcomes.

Another benefit of the CHERI may be seen in advancing theory development and testing. For instance, resource mobilization and energy conservation are crucial aspects in the field of self-control research (e.g., Baumeister et al., 2018). However, the concept of mental strength as a depletable resource has long been debated, primarily due to challenges in replicating empirical evidence (Vohs et al., 2021; Wolff et al., 2018) and addressing theoretical and conceptual issues concerning the mechanics of self-control failure and the nature of the underlying resource (Bertrams, 2020). Novel models, such as Bertrams' (2020) schema model of self-control, integrate physiological and affective-motivational processes to explain self-control failure. According to this model, the motivation to conserve energy acts as one mediator, among other variables, between initial self-control performance and subsequent self-control failure. This suggests that individuals discontinue exerting self-regulation effort because of their motivation to save energy resources. Our newly developed scale, the CHERI, could effectively enhance the evaluation of theoretical frameworks relying on energy conservation paradigms within experimental research designs.

Although the present research provides valuable insights, it is not without limitations. For example, we observed a wide variation in the validation criteria's coefficient magnitudes, with many indicating discriminant validity through low to medium-sized correlations to variables distal in the nomological network. Therefore, further research is needed to gather additional evidence for convergent validity. One promising avenue is to explore the CHERI's relationship with individuals' willingness to invest cognitive effort, using direct measures like cognitive effort-discounting (COG-ED) procedures. In COG-ED, participants repeatedly decide between performing a low-effort task for minimal compensation or a high-effort task for a larger reward until both options are equally preferred (e.g., Westbrook et al., 2013). This procedure provides insight into how individuals value their effort. Investigating the extent to which the CHERI aligns with such direct measures would be of considerable interest.

While our research successfully demonstrated the CHERI's sensitivity to change using a two-wave design, it is important to note that part of the conclusions about the nature of the construct is drawn from cross-sectional data at the between-level. Despite the CHERI's instruction emphasizing momentary motivation, it remains uncertain how much of the trait variance is captured by the measure. Thus, for further validation, future research should explore the CHERI's psychometric properties using designs that incorporate experience sampling methods (ESM). Such methods would provide valuable data suitable for running latent state-trait (LST) analyses, allowing to differentiate between within- and between-person variance unique to the construct (e.g., Steyer et al., 2015). Moreover, conducting ESM or diary studies would not only permit to make more conclusive statements about the nature of the construct but also contribute to theory development. For example, providing more detailed insights into the day-to-day or within-day variations in the motivation to conserve energy might help to explore the proximity of the motivation to conserve energy more precisely. In other words, one might want to investigate the extent to which individuals prepare in advance to save up their energy reserves for goal-attainment, providing valuable information about the planning horizon individuals employ when it comes to effort mobilization. This line of inquiry can shed light on whether individuals possess a short-term perspective, conserving energy only for immediate needs and short-duration goals, or if they exhibit a more forward-thinking approach, proactively allocating resources over a longer period to ensure they have sufficient energy for important and long-term objectives (e.g., Muraven et al., 2016). By investigating the temporal dynamics of energy conservation, researchers may enhance our understanding of how individuals make informed or even unconscious decisions about when to mobilize resources and when to conserve energy for future demands.

## Conclusions

The validation study of the CHERI has yielded promising results, establishing its value as a measurement tool. The scale, comprising only five items, effectively captures individuals'

momentary motivation to conserve their energy resources. The present work provides substantial evidence for the reliability and validity of the CHERI, affirming its sound psychometric properties. Moreover, the CHERI exhibits notable advantages, including brevity and adaptability, enhancing its practical utility. Its versatile implementation in various psychological research and practice contexts further underscores the CHERI's potential impact in the field of effort mobilization and energy conservation.

## Disclosure Statement

The authors report there are no competing interests to declare.

## Data Availability Statement

The raw data that support the findings of this study are openly available at https://researchbox.org/1877, reference number 1877.

## Acknowledgements

We sincerely thank Larissa Dooley, Michael Jennings, Oliver Exall, Philip Pearce, and Sara Möser for their invaluable help in translating the CHERI. Your contributions are greatly appreciated.

## Funding

This study was conducted without receiving any external funding.

**References**

Aust, F., Diedenhofen, B., Ullrich, S., & Musch, J. (2013). Seriousness checks are useful to improve data validity in online research. *Behavior Research Methods*, *45*, 527–535. https://doi.org/10.3758/s13428-012-0265-2

Baumeister, R. F., Tice, D. M., & Vohs, K. D. (2018). The strength model of self-regulation: Conclusions from the second decade of willpower research. Perspectives on Psychological Science, 13, 141–145. https://doi.org/10.1177/1745691617716

Beaton, D. E., Bombardier, C., Guillemin, F., & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine*, *25*, 3186–3191.https://doi.org/10.1097/00007632-200012150-00014

Beavers, A. S., Lounsbury, J. W., Richards, J. K., Huck, S. W., Skolits, G. J., & Esquivel, S. L. (2013). Practical considerations for using exploratory factor analysis in educational research. *Practical Assessment, Research, and Evaluation, 18*, 6. https://doi.org/10.7275/qv2q-rk76

Behr, D. (2017). Assessing the use of back translation: The shortcomings of back translation as a quality testing method. *International Journal of Social Research Methodology*, *20*, 573–584. http://dx.doi.org/10.1080/13645579.2016.1252188

Bertrams, A. (2020). A schema-activation approach to failure and success in self-control. *Frontiers in Psychology*, *11*, 2256. https://doi.org/10.3389/fpsyg.2020.02256

Bertrams, A., Dyllick, T. H., Englert, C., & Krispenz, A. (2020). German adaptation of the subjective vitality scales (SVS-G). *Open psychology*, *2*, 57–75. https://doi.org/10.1515/psych-2020-0005

Blaise, M., Marksteiner, T., Krispenz, A., & Bertrams, A. (2021). Measuring motivation for cognitive effort as state. *Frontiers in Psychology*, 5842. https://doi.org/10.3389/fpsyg.2021.785094

Boksem, M. A., & Tops, M. (2008). Mental fatigue: costs and benefits. *Brain Research Reviews*, *59*, 125–139. https://doi.org/10.1016/j.brainresrev.2008.07.001

Burdenski Jr, T. K. (2000). Evaluating univariate, bivariate, and multivariate normality using graphical procedures. *Multiple Linear Regression Viewpoints*, *26*, 15–28.

Briggs, S. R., & Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality*, *54*, 106–148. https://doi.org/10.3758/s13428-012-0265-2

Brehm, J. W., & Self, E. A. (1989). The intensity of motivation. *Annual Review of Psychology*, *40*, 109–131. https://doi.org/10.1146/annurev.ps.40.020189.000545

Brown, T. A. (2015). *Confirmatory factor analysis for applied research*. Guilford Publications.

Cambridge University Press. (n.d.). Strength. In Cambridge Dictionary. Retrieved December 12, 2023, from https://dictionary.cambridge.org/dictionary/english/strength

Cheung, G. W., & Wang, C. (2017). Current approaches for assessing convergent and discriminant validity with SEM: Issues and solutions. *Academy of Management Proceedings*, *2017*, 12706. https://doi.org/10.5465/AMBPP.2017.12706abstract

Chevalier, N. (2018). Willing to think hard? The subjective value of cognitive effort in children. *Child Development*, *89*, 1283–1295. https://doi.org/10.1111/cdev.12805

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum Associates.

Comrey, A. L., & Lee, H. B. (1992). *A first course in factor analysis* (2nd ed.). Erlbaum.

Costello, A. B., & Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, Research, and Evaluation*, *10*, 7. https://doi.org/10.7275/jyj1-4868

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin, 52*, 281–302. https://doi.org/10.1037/h0040957

De Bloom, J., Kinnunen, U., & Korpela, K. (2015). Recovery processes during and after work. *Journal of Occupational and Environmental Medicine*, *57*, 732–742. https://doi.org/10.1097/JOM.0000000000000475

DeepL. (2021, November 1). *How does DeepL work?* https://www.deepl.com/en/blog/how-does-deepl-work

Demerouti, E., Bakker, A. B., Sonnentag, S., & Fullagar, C. J. (2012). Work-related flow and energy at work and at home: A study on the role of daily recovery. *Journal of Organizational Behavior*, *33*, 276–295. https://doi.org/10.1002/job.760

DeVellis, R. F. (2017). *Scale development: Theory and applications (4th Edn.)*. Sage Publications.

Dunn, J., & Grider, M. H. (2023, August 11). *Physiology, adenosine triphosphate.* National Library of Medecine. https://www.ncbi.nlm.nih.gov/books/NBK553175/

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, *70*, 461–475. https://doi.org/10.1037/0022-3514.70.3.461

Epstein, J., Osborne, R. H., Elsworth, G. R., Beaton, D. E., & Guillemin, F. (2015). Cross-cultural adaptation of the Health Education Impact Questionnaire: experimental study

showed expert committee, not back-translation, added value. *Journal of Clinical Epidemiology*, *68*, 360–369. http://dx.doi.org/10.1016/j.jclinepi.2013.07.013

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Field, A. (2018). *Discovering statistics using IBM SPSS statistics (5th Edn.)*. Sage Publications.

Fritz, C., Ellis, A. M., Demsky, C. A., Lin, B. C., & Guros, F. (2013). Embracing work breaks. *Organizational Dynamics*, *42*, 274–280. http://dx.doi.org/10.1016/j.orgdyn.2013.07.005

Fritz, C., Lam, C. F., & Spreitzer, G. M. (2011). It's the little things that matter: An examination of knowledge workers' energy management. *The Academy of Management Perspectives, 25*, 28–39. https://doi.org/10.5465/amp.25.3.zol28

Gendolla, G. H., & Richter, M. (2010). Effort mobilization when the self is involved: Some lessons from the cardiovascular system. *Review of General Psychology*, *14*, 212–226. https://doi.org/10.1037/a0019742

Giacomantonio, M., Jordan, J., & Fennis, B. M. (2019). Intense self-regulatory effort increases need for conservation and reduces attractiveness of energy-requiring rewards. *Social Psychology, 50*, 355–369. https://doi.org/10.1027/1864-9335/a000395

Gray, W. D., Sims, C. R., Fu, W. T., & Schoelles, M. J. (2006). The soft constraints hypothesis: a rational analysis approach to resource allocation for interactive behavior. *Psychological Review*, *113*, 461. https://doi.org/10.1037/0033-295X.113.3.461

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Advances in Psychology*, *52*, 139–183. https://doi.org/10.1016/S0166-4115(08)62386-9

Hooper, D., Coughlan, J., & Mullen, M. (2008). *Evaluating model fit: A synthesis of the structural equation modelling literature.* In A. Brown (Ed.), 7th European Conference on research methodology for business and management studies (pp. 195–200). Academic Publishing Limited.

Hülsheger, U. R. (2016). From dawn till dusk: Shedding light on the recovery process by investigating daily change patterns in fatigue. *Journal of Applied Psychology*, *101*, 905–914. https://doi.org/10.1037/apl0000104

Husted, J. A., Cook, R. J., Farewell, V. T., & Gladman, D. D. (2000). Methods for assessing responsiveness: A critical review and recommendations. *Journal of Clinical Epidemiology*, *53*, 459–468. https://doi.org/10.1016/S0895-4356(99)00206-1

Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion—Is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*, 1686-1693. https://doi.org/10.1177/0956797610384745

Kinnunen, U., Feldt, T., de Bloom, J., & Korpela, K. (2015). Patterns of daily energy management at work: relations to employee well-being and job characteristics. *International Archives of Occupational and Environmental Health*, *88*, 1077–1086. https://doi.org/10.1007/s00420-015-1039-9

Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology: General*, *139*, 665–682. https://doi.org/10.1037/a0020198

Korkmaz, S., Göksülük, D., & Zararsiz, G. (2014). MVN: An R package for assessing multivariate normality. *R Journal*, *6*, 151–162. https://doi.org/10.32614/RJ-2014-031

Kosenkranius, M., Rink, F., Weigelt, O., & de Bloom, J. (2023). Crafting and human energy: Needs-based crafting efforts across life domains shape employees' daily energy trajectories. *Journal of Occupational Health Psychology*, *28*, 192–204. https://doi.org/10.1037/ocp0000347

Kühnel, J., Zacher, H., De Bloom, J., & Bledow, R. (2017). Take a break! Benefits of sleep and short breaks for daily work engagement. *European Journal of Work and Organizational Psychology*, *26*, 481–491. https://doi.org/10.1080/1359432X.2016.1269750

Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences*, *36*, 661–679. https://doi.org/10.1017/S0140525X12003196

Lang, J. W., & Fries, S. (2006). A revised 10-item version of the Achievement Motives Scale. *European Journal of Psychological Assessment*, *22*, 216–224. https://doi.org/10.1027/1015-5759.22.3.216

Leitgöb, H., Seddig, D., Asparouhov, T., Behr, D., Davidov, E., De Roover, K., ... & van de Schoot, R. (2022). Measurement invariance in the social sciences: Historical development, methodological challenges, state of the art, and future perspectives. *Social Science Research*, 102805. https://doi.org/10.1016/j.ssresearch.2022.102805

Maslach, C., & Jackson, S. E. (1981). The measurement of experienced burnout. *Journal of Organizational Behavior*, *2*, 99–113.https://doi.org/10.1002/job.4030020205

Maslach, C., Schaufeli, W. B., & Leiter, M. P. (2001). Job burnout. *Annual Review of Psychology*, *52*, 397–422. https://doi.org/10.1146/annurev.psych.52.1.397

Mecklin, C. J., & Mundfrom, D. J. (2005). A Monte Carlo comparison of the Type I and Type II error rates of tests of multivariate normality. *Journal of Statistical Computation and Simulation*, *75*, 93–107. https://doi.org/10.1080/0094965042000193233

Meade, A. W., & Craig, S. B. (2012). Identifying careless responses in survey data. *Psychological Methods*, *17*, 437–455. https://doi.org/10.1037/a0028085

Muraven, M., Shmueli, D., & Burkley, E. (2006). Conserving self-control strength. *Journal of Personality and Social Psychology*, *91*, 524–537. https://doi.org/10.1037/0022-3514.91.3.524

Muthén, B., & Kaplan, D. (1985). A comparison of some methodologies for the factor analysis of non-normal likert variables. *British Journal of Mathematical and Statistical Psychology*, *38*, 171–189. https://doi.org/10.1111/j.2044-8317.1985.tb00832.x

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments & Computers, 32*, 396–402. https://doi.org/10.3758/BF03200807

Op den Kamp, E. M., Tims, M., Bakker, A. B., & Demerouti, E. (2018). Proactive vitality management in the work context: Development and validation of a new instrument. *European Journal of Work and Organizational Psychology, 27*, 493–505. https://doi.org/10.1080/1359432X.2018.1483915

OpenAI. (2023, November 10). *GPT-4*. https://platform.openai.com/docs/guides/text-generation

Osborne, J. W. (2014). *Best practices in exploratory factor analysis*. CreateSpace Independent Publishing.

Oxford University Press. (n.d.). Strength. In Oxford English Dictionary Online. Retrieved December 12, 2023, from https://www.oed.com/dictionary/strength_n?tab=meaning_and_use#20576583

Parker, S. L., Zacher, H., de Bloom, J., Verton, T. M., & Lentink, C. R. (2017). Daily use of energy management strategies and occupational well-being: The moderating role of job demands. *Frontiers in Psychology*, *8*, 1477. https://doi.org/10.3389/fpsyg.2017.01477

Penfield, R. D., (2013). Item analysis. In K. F. Geisinger, B. A Bracken, J. F. Carlson, J.-I. C. Hansen, N. R. Kuncel, S. P. Reise, & M. C. Rodriguez (Eds.), *APA handbook of testing and assessment in psychology, Vol 1: Testing and assessment in clinical and counseling psychology* (pp. 121–138). American Psychological Association. https://doi.org/10.1037/14049-000

Putnick, D. L., & Bornstein, M. H. (2016). Measurement invariance conventions and reporting: The state of the art and future directions for psychological research. *Developmental Review*, *41*, 71–90. https://doi.org/10.1016/j.dr.2016.06.004

Quinn, R. W., Spreitzer, G. M., & Lam, C. F. (2012). Building a sustainable model of human energy in organizations: Exploring the critical role of resources. *Academy of Management Annals*, *6*, 337–396. https://doi.org/10.5465/19416520.2012.676762

Ramzan, S., Zahid, F. M., & Ramzan, S. (2013). Evaluating multivariate normality: A graphical approach. *Middle East Journal of Scientific Research*, *13*, 254–263. https://doi.org/10.5829/idosi.mejsr.2013.13.2.1746

Roskes, M., De Dreu, C. K., & Nijstad, B. A. (2012). Necessity is the mother of invention: avoidance motivation stimulates creativity through cognitive effort. *Journal of Personality and Social Psychology*, *103*, 242–256. https://doi.org/10.1037/a0028442

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*, 1–36. https://doi.org/10.18637/jss.v048.i02

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality psychology compass*, *2*, 702–717. https://doi.org/10.1111/j.1751-9004.2008.00098.x

Ryan, R. M., & Frederick, C. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*, 529–565. https://doi.org/10.1111/j.1467-6494.1997.tb00326.x

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*, *66*, 507–514. https://doi.org/10.1007/BF02296192

Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and Psychological Measurement, 66*, 701–716. https://doi.org/10.1177/0013164405282471

Sianoja, M., Kinnunen, U., Bloom, J. D., Korpela, K., & Geurts, S. A. E. (2016). Recovery during lunch breaks: Testing long-term relations with energy levels at work. *Scandinavian Journal of Work and Organizational Psychology, 1,* 1–12. *http://dx.doi.org/10.16993/sjwop.13*

Sonnentag, S., Cheng, B. H., & Parker, S. L. (2022). Recovery from work: Advancing the field toward the future. *Annual Review of Organizational Psychology and Organizational Behavior*, *9*, 33–60. https://doi.org/10.1146/annurev-orgpsych-012420-091355

Steyer, R., Mayer, A., Geiser, C., & Cole, D. A. (2015). A theory of states and traits—revised. *Annual Review of Clinical Psychology*, *11*, 71–98. https://doi.org/10.1146/annurev-clinpsy-032813-153719

Streiner, D. L. (2003). Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment*, *80*, 99–103. https://doi.org/10.1207/S15327752JPA8001_18

Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (*7thEdn.).* Pearson.

Van Veldhoven, M. J. P. M., & Broersen, S. (2003). Measurement quality and validity of the "need for recovery scale". *Occupational and Environmental Medicine, 60*, i3-i9. http://dx.doi.org/10.1136/oem.60.suppl_1.i3

Velicer, W. F., Eaton, C., & Fava, J. (2000). Construct explication through factor or component analysis: A review and evaluation of alternative procedures for determining the number of factors or components. In R. Goffin & E. Helmes (Eds.), *Problems and solutions in human assessment* (pp. 41–71). Springer US.

Weigelt, O., Gierer, P., Prem, R., Fellmann, M., Lambusch, F., Siestrup, K., Marcus, B., Franke, T., Tsantidis, S., Golla, M., Wyss, C., & Blume, J. (2022). Time to recharge batteries–development and validation of a pictorial scale of human energy. *European Journal of Work and Organizational Psychology*, *31*, 781–798. https://doi.org/10.1080/1359432X.2022.2050218

Vohs, K. D., Schmeichel, B. J., Lohmann, S., Gronau, Q. F., Finley, A. J., Ainsworth, S. E., Alquist, J. L., Baker, M. D., Brizi, A., Bunyi, A., Butschek, G. J., Campbell, C., Capaldi, J., Cau, C., Chambers, H., Chatzisarantis, N. L. D., Christensen, W. J., Clay, S. L., Curtis, J., Albarracín, D. (2021). A multisite preregistered paradigmatic test of the ego-depletion effect. *Psychological Science*, *32*, 1566–1581. https://doi.org/10.1177/09567976219897

Wolff, W., Baumann, L., and Englert, C. (2018). Self-reports from behind the scenes: questionable research practices and rates of replication in ego depletion research. *PLoS ONE,* 13:e0199554. https://doi.org/10.1371/journal.pone.0199554

Westbrook, A., Kester, D., & Braver, T. S. (2013). What is the subjective cost of cognitive effort? Load, trait, and aging effects revealed by economic preference. *PloS ONE*, *8*, e68210. https://doi.org/10.1371/journal.pone.0068210

Zacher, H., Brailsford, H. A., & Parker, S. L. (2014). Micro-breaks matter: A diary study on the effects of energy management strategies on occupational well-being. *Journal of Vocational Behavior*, *85*, 287–297. https://doi.org/10.1016/j.jvb.2014.08.005

**Table 1.** Item Wordings and Descriptive Statistics of the CHERI-G in Study 1

| | Item wording (English/*German*) | *M* | *SD* | λ | $r_{it}$ |
|---|---|---|---|---|---|
| How are you feeling at the moment? Right now, I want to…<br>*Wie fühlen Sie sich im Moment? Gerade möchte ich…* | | | | | |
| 01 | …save my energy resources.<br>*…meine Energiereserven sparen.* | 3.67 | 1.32 | .76 | .72 |
| 02 | …drain as little of my "battery" as possible.<br>*…möglichst wenig meinen "Akku" anzapfen.* | 3.56 | 1.40 | .82 | .78 |
| 03 | …switch to my "energy saving mode".<br>*…in meinen "Energiesparmodus" schalten.* | 3.41 | 1.55 | .74 | .71 |
| 04 | …conserve my strength.<br>*…meine Kräfte schonen.* | 3.64 | 1.45 | .85 | .81 |
| 05 | …use as little of my energy as possible.<br>*…so wenig wie möglich von meiner Energie verbrauchen.* | 3.35 | 1.46 | .86 | .81 |
| 06 | …invest as little energy as possible.<br>*…möglichst keine Energie investieren.* | 2.90 | 1.48 | .77 | .73 |
| | CHERI-G | 3.42 | 1.44 | | |

*Note.* $N = 321$. λ = factor loading extracted from PAF. $r_{it}$ = corrected item-total correlation.

**Table 2.** Descriptive Statistics and State-Trait-Intercorrelations for Study 2 Validation Criteria

| | | | | | | Intercorrelations [95 % bootstrapped CIs][a] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measure | Dimension of measurement | *M* | *SD* | ω | 01 | 02 | 03 | 04 | 05 | 06 |
| 01 | CHERI-G (5 items) | state | 3.55 | 1.07 | .95 | – | | | | | |
| 02 | Motivation for Cognitive Effort | state | 3.69 | 0.86 | .90 | –.38*** [–.45, –.30] | – | | | | |
| 03 | Subjective Vitality | state | 3.70 | 1.10 | .91 | –.51*** [–.58, –.45] | .41*** [.34, .48] | – | | | |
| 04 | Energetic Activation | state | 4.30 | 1.18 | – | –.46*** [–.53, –.39] | .33*** [.26, .41] | .74*** [.70, .78] | – | | |
| 05 | Implicit Theories of Willpower | trait | 2.86 | 0.72 | .91 | –.18*** [–.26, –.09] | .30*** [.21, .37] | .17*** [.08, .26] | .11* [.02, .19] | – | |
| 06 | Fear of Failure | trait | 2.66 | 0.65 | .86 | .24*** [.16, .32] | –.33*** [–.40, –.26] | –.32*** [–.40, –.24] | –.25*** [–.32, –.16] | –.26*** [–.34, –.18] | – |
| 07 | Hope for Success | trait | 3.20 | 0.44 | .79 | –.15*** [–.24, –.06] | .33*** [.27, .40] | .26*** [.19, .33] | .14*** [.06, .22] | .16*** [.08, .24] | –.25** [–.33, –.17] |

*Note.* $N = 576$. CHERI-G = German Conservation of Human Energy Resources Index (5 items). Displayed are Pearson's correlation coefficients. *$p < .05$, **$p < .01$, ***$p < .001$. For the correlations between the CHERI-G and the six validation criteria, we considered Bonferroni adjusted $p$ values < .008 (two-tailed) as statistically significant. [a] Bias-corrected and accelerated (BCa) method with 5,000 resamples.

**Table 3.** Goodness-of-Fit Statistics of the Three Estimated Models in Study 2

| model description | MLM$\chi^2$ (*df*) | RMSEA (*90% CI*) | CFI | TLI | SRMR | Δ MLM$\chi^2$ (*df*) | |
|---|---|---|---|---|---|---|---|
| | | | | | | model comparison | $\Delta\chi^2$ ($\Delta df$) |
| M1: 6 initial items | 57.25(9)*** | 0.096 (0.079 – 0.115) | 0.978 | 0.963 | 0.028 | - - | - - |
| M2: 6 items, covariance between items 5 and 6 | 33.08(8)*** | 0.074 (0.055 – 0.094) | 0.989 | 0.978 | 0.020 | M1-M2 | 27.57(1)*** |
| M3: 5 items, item 6 omitted | 21.58(5)** | 0.076 (0.053 – 0.100) | 0.991 | 0.983 | 0.016 | - - | - - |

*Note.* $N = 576$. $\Delta$MLM$\chi^2$ = scaled chi-square difference test using maximum likelihood mean-adjusted estimation (MLM). $\Delta df$: difference in degrees of freedoms. *$p < .05$, **$p < .01$, ***$p < .001$, *n.s.* = not significant.

**Table 4.** Item Wordings and Descriptive Statistics of the English CHERI-E in Study 4

| Item wording | | *M* | *SD* | $r_{it}$ |
|---|---|---|---|---|
| How are you feeling at the moment? Right now, I want to… | | | | |
| 01 | …save my energy resources. | 3.86 | 1.32 | 0.86 |
| 02 | …drain as little of my “battery” as possible. | 3.89 | 1.43 | 0.83 |
| 03 | …switch to my “energy saving mode”. | 3.75 | 1.46 | 0.87 |
| 04 | …conserve my strength. | 3.93 | 1.39 | 0.89 |
| 05 | …use as little of my energy as possible. | 3.82 | 1.45 | 0.89 |
| | CHERI-E | 3.85 | 1.41 | |

*Note.* $N = 592$. $r_{it}$ = corrected item-total correlation.

**Table 5.** Fit Indices of the MGCFA in Study 4

| **Model** | **MLM$\chi^2$ (*df*)** | **CFI** | **RMSEA (90% CI)** | **Model comp.** | **$\Delta\chi^2$ ($\Delta df$)** | **ΔCFI** | **ΔRMSEA** | **Decision** |
|---|---|---|---|---|---|---|---|---|
| M1: Configural Invariance | $38.40^{***}$(10) | 0.993 | 0.070 (0.053–0.087) | -- | -- | -- | -- | -- |
| M2: Metric Invariance | $58.14^{***}$(15) | 0.989 | 0.070 (0.055–0.086) | M1 | $19.76^{**}$(5) | 0.004 | 0.000 | Accept |
| M3: Scalar Invariance | $87.84^{***}$(19) | 0.983 | 0.079 (0.065–0.093) | M2 | $29.69^{***}$ (4) | 0.006 | 0.009 | Accept |

*Note. MGCFA = Multi-Group Confirmatory Factor Analysis.* $N_{total} = 1168$, $n_{GER} = 576$, $n_{ENG} = 592$. *$p < .05$, **$p < .01$, ***$p < .001$.

**Table 6.** Descriptive Statistics and Intercorrelations for Study 4 Validation Criteria

| | | | | | Intercorrelations [95 % bootstrapped CIs][a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measure | *M* | *SD* | ω | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 |
| 01 | CHERI-E (5 items) | 3.85 | 1.27 | .95 | – | | | | | | | |
| 02 | Emotional Exhaustion | 3.70 | 1.51 | .96 | .40*** [.32, .47] | – | | | | | | |
| 03 | NFR | 51.95 | 32.29 | .90 | .44*** [.37, .51] | .74*** [.71, .78] | | | | | | |
| 04 | PVM | 4.70 | 1.32 | .94 | –.17*** [–.25, –.07] | –.37*** [–.44, .–30] | –.33*** [–.40, –.27] | | | | | |
| 05 | Vigor | 4.24 | 1.34 | .88 | –.27*** [–.35, –.20] | –.57*** [–.63, .–52] | –.43*** [–.49, –.36] | .61*** [55, .66] | | | | |
| 06 | EMS, micro-breaks | 3.15 | 1.00 | .79 | .03 [–.05, .12] | –.01 [–.09, .07] | –.01 [–.09, .07] | .28*** [.22, .34] | .18*** [.10, .25] | | | |
| 07 | EMS, work related | 2.79 | 1.05 | .67 | –.05 [–.14, .03] | –.18*** [–.26, –.10] | –.12 [–.20, –.04] | .49*** [.44, .54] | .35*** [.28, .42] | .59*** [.54, .65] | | |
| 08 | Gender (female / male) | – | – | – | .12** [.04, .19] | .05 [–.04, .13] | .08 [–.01, .18] | .00 [–.06, .07] | –.04** [–.12, .03] | –.05 [–.12, .04] | .00 [–.06, .08] | |
| 09 | age | – | – | – | –.20*** [–.27, –.12] | –.20*** [–.28, –.12] | –.17*** [–.24, –.09] | .15*** [.07, .22] | .16*** [.10, .24] | –.02 [–.11, .06] | .01 [–.08, .08] | –.09* [–.21, –.02] |

*Note.* $N$ =566–592. CHERI-E = English Conservation of Human Energy Resources Index (5 items). EMS = Energy Management Strategies. NFR = Need for Recovery. PVM = Proactive Vitality Management. Displayed are Pearson's correlation coefficients. *$p < .05$, **$p < .01$, ***$p < .001$. For the correlations between the CHERI-E and the five validation criteria, we considered Bonferroni adjusted $p$ values < .0063 (two-tailed) as statistically significant.[a] Bias-corrected and accelerated (BCa) method with 5,000 resamples.

**Supplemental Note SN1.** Translation Process of the CHERI-E

The translation procedure was carried out in compliance with the guidelines provided by Beaton et al. (2000) and consisted of four essential steps.

*In step one,* we engaged two independent translators who provided translations, "$T1_A$" and "$T2_B$", into the target language. Both translators were native English speakers and had spent many years living, studying, and working in German-speaking regions of Europe. Simultaneously, we had DeepL-Pro and GPT-4 do a translation, "$T1_{DPL}$" and "$T2_{GPT}$".

Step two involved reconciling any discrepancies between the final reports submitted by the translators and synthesizing these translations into a unified version. The divergences between $T1_A$ and $T2_B$ were minimal, predominantly of a stylistic nature such as "drain my battery" versus "draw on my battery". The machine-supported translations $T1_{DPL}$ and $T1_{GPT}$ were almost identical, so that the synthesis could be carried out with minimal changes. It is particularly noteworthy that the human synthesis from $T1_A$/$T2_B$ differed from the computerized $T1_{DPL}$/$T2_{GPT}$ only in item number two ("drain my battery" vs. "tap into my battery").

*Step three*, involving back-translation, was preserved in the process to maintain comprehensiveness, despite the ongoing discourse on the method's effectiveness in questionnaire translations (e.g., Behr, 2017; Epstein et al., 2015). In this phase, three other independent bilingual English-German translators provided back-translations ($BT_1$, $BT_2$, and $BT_3$). Their back-translations and accompanying comments demonstrated that the content of all items had been accurately preserved throughout the translation process, ensuring there was no loss of information. As was to be expected, DeepL-Pro and GPT-4 returned the synthetized translation almost perfectly to the original.

The fourth and final step involved an expert committee review, comprising the three study authors, two of the three back-translators, and an addition bilingual speaker, that was not familiar with the topic. This step was instrumental in fine-tuning the translation, incorporating minor adjustments made during the synthesis phase.

**Supplemental Table S1.** Descriptive Statistics of the CHERI-G in Study 2

| Item | *M* | *SD* | Skewness | Kurtosis |
|---|---|---|---|---|
| 01 | 3.82 | 1.13 | –0.10 | –0.32 |
| 02 | 3.62 | 1.22 | 0.05 | –0.66 |
| 03 | 3.58 | 1.32 | 0.10 | –0.71 |
| 04 | 3.70 | 1.21 | –0.08 | –0.60 |
| 05 | 3.47 | 1.23 | 0.11 | –0.55 |
| 06 | 3.10 | 1.27 | 0.36 | –0.37 |

*Note.* $N = 576$. $SE_{skewness} = .10$ and $SE_{kurtosis} = .20$.

**Supplemental Table S2**. Sample Demographics, Means (M), and Standard Deviations (SD) in Study 4

| | *N* | *M* | *SD* | *%* |
|---|---|---|---|---|
| Age (years) | 592 | 40.48 | 11.46 | – |
| Gender | | | | |
| Female | 291 | – | – | 49.1 |
| Male | 297 | – | – | 50.2 |
| Other | 4 | – | – | 0.7 |
| Language(s) | | | | |
| English | 494 | – | – | 83.4 |
| English and another language | 98 | – | – | 16.6 |
| Time/duration | | | | |
| Average weekly working hours | – | 39.47 | 5.72 | – |
| Work hours on survey day | – | 7.98 | 3.01 | – |
| Years of professional experience | – | 13.23 | 10.8 | – |
| Tenure with current organization | – | 8.70 | 9.35 | – |
| Type of contract/employment status | | | | |
| On parental leave / on sabbatical | 3 | – | – | 0.5 |
| Permanent work contract | 538 | – | – | 90.9 |
| Temporary contract | 17 | – | – | 2.9 |
| Intern/apprentice | 1 | – | – | 0.2 |
| Self-employed | 30 | – | – | 5.1 |
| Unemployed | – | – | – | – |
| Student | 2 | – | – | 0.3 |
| Retired | – | – | – | – |
| Other | 1 | – | – | 0.2 |
| Professions/industries | | | | |
| Business | 26 | – | – | 4.4 |
| Construction | 35 | – | – | 5.9 |
| Education | 87 | – | – | 14.7 |
| Finance & Banking | 14 | – | – | 2.4 |
| Government and Public Administration | 62 | – | – | 10.5 |
| Healthcare and Medical Services | 63 | – | – | 10.6 |
| Information Technology (IT) | 64 | – | – | 10.8 |
| Leisure and Hospitality | 22 | – | – | 3.7 |
| Manufacturing | 41 | – | – | 6.9 |
| Retail Trade | 36 | – | – | 6.1 |
| other | 96 | – | – | 16.2 |

**Table S2** (continued)

| | *N* | *M* | *SD* | *%* |
|---|---|---|---|---|
| Marital Status | | | | |
| Single (never married) | 184 | – | – | 31.1 |
| Married (first marriage) | 208 | – | – | 35.1 |
| Remarried | 13 | – | – | 2.2 |
| Separated | 7 | – | – | 1.2 |
| Divorced | 28 | – | – | 4.7 |
| Widowed | 1 | – | – | 0.2 |
| Long-term domestic partner (at least one year) | 146 | – | – | 24.7 |
| Highest Educational Level | | | | |
| Professional degree (JD, MD) | 12 | – | – | 2.0 |
| Doctoral degree | 13 | – | – | 2.2 |
| Master's degree | 110 | – | – | 18.6 |
| Bachelor's degree in college (4-year) | 240 | – | – | 40.5 |
| Associate degree in college (2-year) | 47 | – | – | 7.9 |
| High school graduate | 155 | – | – | 26.2 |
| Less than high school degree | 7 | – | – | 1.2 |
| Other | 8 | – | – | 1.4 |

**Figure SF1**. Factor Structures and Standardized Estimates for Models M1–M3 of the CHERI-G in Study 2

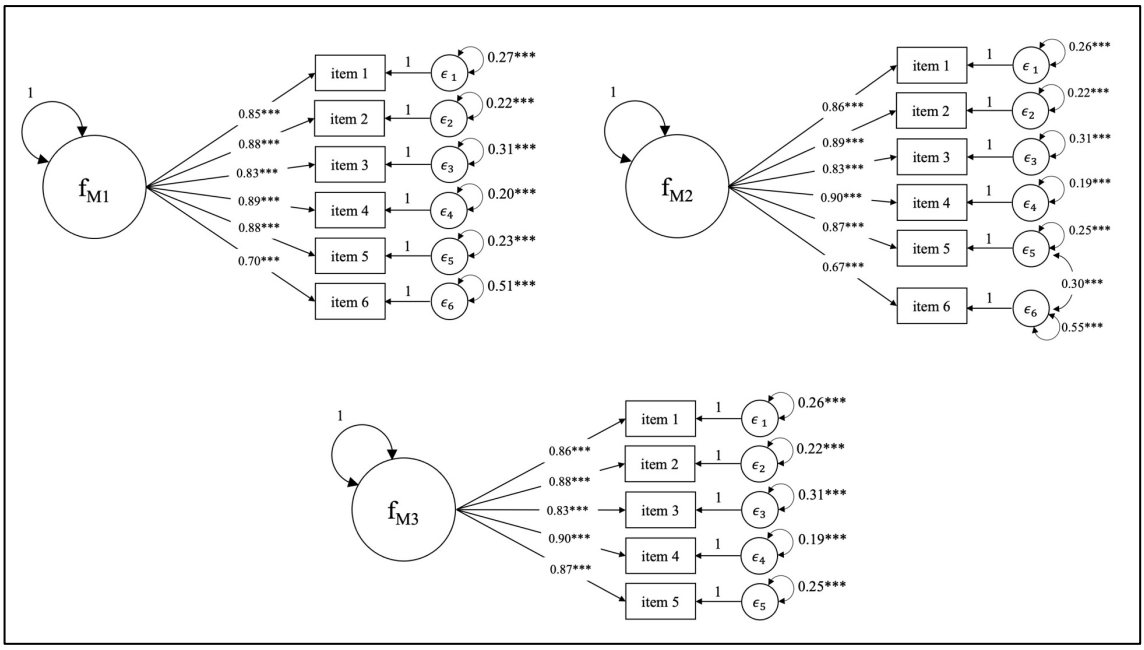
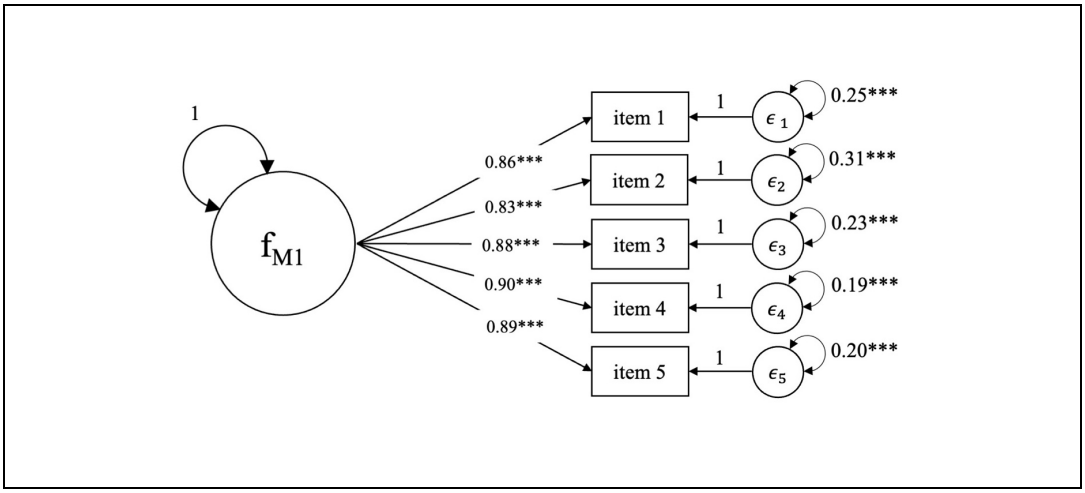


**Figure SF2.** Factor structure and standardized estimates of the CHERI-E in Study 4



# The Mental Association Between Subjective Vitality, Energy Conservation Motivation, and Cognitive Effort Motivation According to the Schema Model of Self-Control

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We have no known conflicts of interest to disclose.

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**Abstract**

According to the schema model of self-control, repetitive self-control efforts falter due to the activation of a reduced vitality schema, resulting in increased motivation for energy conservation and reduced cognitive efforts. Drawing on these assumptions, we conducted two randomized control studies aimed at examining the mental associations individuals establish between subjective vitality, the motivation to conserve energy, and cognitive motivation. In both studies, the participants were presented with vignettes with fictitious characters described as either vital or nonvital. In Study 1 ($N = 487$), participants attributed higher motivation to conserve energy and lower motivation for cognitive effort to the character described as having low, compared to high, subjective vitality. Furthermore, the motivation to conserve energy was found to partially mediate the relationship between subjective vitality and cognitive motivation, aligning with the schema model's predictions. Study 2 ($N = 449$) successfully replicated the findings of Study 1 using different measures. Overall, the results establish a promising foundation for investigating the schema model of self-control at a behavioral level, since the mental representations can be regarded as precursors that prompt individuals to translate their cognitive concepts into corresponding actions.

*Keywords:* self-control, schema model, subjective vitality, energy conservation, cognitive motivation

## The Mental Association Between Subjective Vitality, Energy Conservation Motivation, and Cognitive Effort Motivation According to the Schema Model of Self-Control

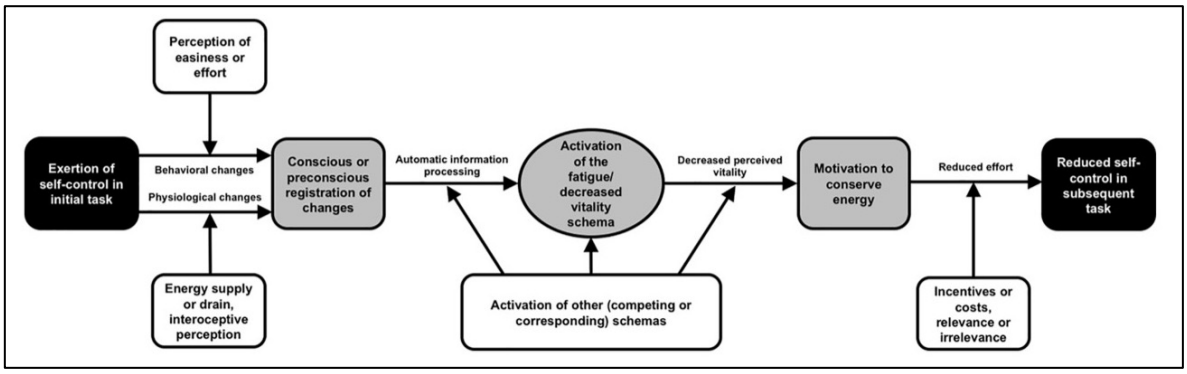
Self-control refers to the ability to inhibit, modify, or overcome automatic or predominant response tendencies, impulses, or emotions (Baumeister et al., 2006; Muraven & Slessareva, 2003). Successfully exerting self-control yields numerous benefits in different aspects of life (De Ridder et al., 2012; Duckworth et al., 2019; Tangney et al., 2004), including academic performance and success (e.g., less school dropout, better course grades at all levels of schooling), interpersonal functioning (e.g., better interpersonal relations and social competence), health-related behaviors (e.g., performing physical exercise, successful dieting, managing substance abuse), affect regulation and deviant behavior (e.g., better anger control, less physical and verbal aggression), and intrapersonal outcomes (e.g., increased well-being and happiness).

Although the exercise of self-control is largely associated with positive outcomes, people nevertheless encounter difficulties in resisting temptations, suppressing impulses, or breaking habits. The risk of self-control failure is notably heightened when individuals have already expended self-regulatory efforts in prior tasks, a phenomenon commonly referred to as the *ego-depletion effect* (Baumeister & Vohs, 2016). In the last two decades, various plausible approaches have been established that focus on the explanation of the ego-depletion effect (e.g., Baumeister et al., 2007; Baumeister & Vohs, 2016; Inzlicht & Schmeichel, 2012; Kurzban et al., 2013). One of the newest of these approaches is Bertrams' (2020) *schema model of self-control* (see Fig. 1), which integrates cognitive, physiological, and affective–motivational process variables to explain self-regulatory failure. According to the model, the central momentum of the ego-depletion effect is the activation of the fatigue/decreased vitality schema. On the one hand, vitality is characterized by a positive, energized state of enthusiasm and aliveness in which individuals possess both physical and mental energy for

purposeful actions (Ryan & Deci, 2008), while on the other, the schema of vitality can be understood as a cognitive structure encompassing "not only facts of knowledge [about vitality] but also affective and motivational elements [of vitality] that guide people's experience and behavior" (Bertrams, 2020, p. 3). We now go on to outline how this schema is activated and how far it affects successful self-regulation.

**Fig. 1**

*The Schema Model of Self-Control*




*Note.* Taken from Bertrams (2020). Black boxes: observable behavior in self-control studies. Gray boxes and horizontal arrows: mediating processes within the individual. White boxes: moderating variables.

First, when effortful self-control is exerted in an initial task, people register—either explicitly and consciously or implicitly and preconsciously—behavioral and physiological changes. For example, they perceive either a shift from easy automatic processing to effortful self-regulation (e.g., behavioral changes) or that exerting self-control causes changes in heart and brain activity (e.g., physiological changes). As a result of these registered changes, a schema of reduced vitality is activated, causing individuals to experience a decline in perceived vitality (i.e., an experiential signal of loss of subjectively available energy for deliberate self-regulation). Upon recognizing that energy reserves may have been consumed in the process, individuals are motivated to conserve their remaining energy. This adaptive response necessitates a reduction in potentially energy-consuming effort, eventually resulting in decreased performance in subsequent tasks requiring self-control. Moderators that can

strengthen and weaken the postulated mechanisms are assumed to have an impact at several points in the model (see Fig. 1, white boxes).

The model is a theoretical framework that is yet to be empirically tested. For this reason, the proposed mental associations underlying the cognitive motivational process between initial and subsequent self-control must first be confirmed. Bertrams (2021) has shown that self-control behavior is mentally associated with perceived fatigue or decreased subjective vitality that serves as a proxy for the level of activation of the fatigue/decreased vitality schema (see left half of Fig. 1). According to the author, a cognitive if–then association is required for translating behavior (e.g., initial self-control) into the assumed information-processing mechanism (e.g., registration of behavioral and physiological changes). A key aspect that remains to be tested is the mental association between decreased subjective vitality (indicating increased activation of the fatigue/decreased vitality schema), the motivation to conserve energy, and the related motivation to reduce effort (see right half of Fig. 1).

Analogous to the first part of the model, it appears that a mental representation of this causal chain is needed for people to translate their mental concepts into corresponding actions. In other words, individuals who have a mental representation of reduced vitality that is associated with increased motivation to conserve energy resources are likely to act accordingly and reduce effort when they feel fatigued. There is compelling evidence that people experience their environment consistently in line with their beliefs and mental representations and behave accordingly. For example, Gainsburg and Lee Cunningham (2023) showed in a series of studies that having a limited-compassion mindset (e.g., believing compassion is limited) predicts lower feelings of compassion. Furthermore, Job et al. (2010) found that compared to people who believe willpower to be an inexhaustible resource, those who hold to the belief that their willpower is exhaustible perform worse in situations where

self-control is required. Taken together, individuals tend to act congruent with their beliefs, making their behavior a reflection of their mental representations. Because these mental images can be regarded as basic premises for behavior, we aim to examine the schema model at a cognitive level.

**The Present Study**

In two studies, we tested two main hypotheses based on the theoretical framework of the *schema model of self-control* described above (Bertrams, 2020). On a general basis, we assumed that individuals have a mental representation in which subjective vitality is causally related to both motivation to save energy and motivation for cognitive effort. Therefore, our first hypothesis was that individuals would attribute significantly lower motivation to conserve energy to a person experiencing high levels of subjective vitality than to a person who experiences low subjective vitality. Our second hypothesis was that participants would attribute higher motivation for cognitive effort to a person with high subjective vitality than to one with low subjective vitality.

To examine the proposed mental associations, we adapted an empirical approach that had been applied in previous research (Bertrams, 2021; Shalev, 2014) and that we viewed as more reliable and valid than the analysis of reaction times that is frequently used (e.g., Mitchell & Tetlock, 2020). In Study 1, we employed a between-subjects design in which participants were randomly assigned to one of two experimental conditions. In each condition, they had to rate a fictitious person. Participants in the low vitality condition received a vitality questionnaire that had been completed by a fictious person and indicated that this person was low in perceived vitality at that moment. Conversely, participants in the high vitality condition received a questionnaire that had been completed by a fictitious person currently with high perceived vitality. After reviewing the prefilled questionnaires, each group rated the

fictitious person's presumed motivation to save energy and their presumed motivation to make cognitive efforts.

Study 2 was conducted using a mixed between-within-subject design and aimed to replicate the findings of Study 1, although it used a different sample and different methods (i.e., different questionnaires and a different study design). As a baseline measure, each participant was presented with a neutral story about an imaginary person seated at their work desk. They were asked to rate this person's motivation to conserve energy and exert cognitive effort. Following this, the participants were randomly assigned to one of two conditions. One group read a story about a character in the same work environment who exhibited signs of high vitality, while the other read about a character who expressed low vitality. Analogous to the first study, the participants then rated their character's motivation to conserve energy and motivation for investing cognitive effort.

## Study 1

Study 1 aimed to investigate the mental associations individuals have regarding subjective vitality, the motivation to conservation energy, and cognitive motivation. In a randomized between-subjects experiment with two conditions, the participants rated the motivation to conserve energy and the motivation to invest in cognitive effort of either a person experiencing high levels of subjective vitality or one experiencing low subjective vitality. Additionally, we wanted to explore the mediating role of energy conservation in the relationship between rated subjective vitality and cognitive motivation.

### Method

#### *Ethical Requirements and Open Science*

Ethical approval was obtained from the human research ethics committee of the University of Bern. All participants provided informed consent and voluntarily took part in the study. They were not compensated in any way through incentives or rewards. The raw

data supporting the findings of Study 1 are available at https://researchbox.org.

### *Participants*

A power analysis conducted using G∗Power 3.1 (Faul et al., 2007) determined that a sample of 242 participants would be necessary to detect a medium-sized effect (e.g., Brysbaert, 2019) with sufficient statistical power (input parameters: *t*-test, independent means, two-tailed, $d = 0.40$, Bonferroni corrected $\alpha = .025$, $1-\beta = .80$). With a total of 495 participants having completed the study, we were assured of a well-powered study design.

Since the survey was conducted online, we carried out a seriousness check, following the recommendation of Aust et al. (2013). We took this step to maintain the integrity of our data and reduce potential biases in our sample. For this purpose, the participants indicated whether they "have taken part seriously" or they "just clicked through" and wished their data to be discarded, with five opting for the latter. Moreover, five participants indicated that they had poor German skills, while two (aged 16 and 99 years) did not meet the age criteria. Taken together, eight participants were excluded from our analysis, leaving a final sample of 487 participants (65.1% female; $M_{age} = 24.94$ years, $SD = 4.55$). The majority of the sample consisted of students (69.1%) and students with part-time jobs (21.9%).

### *Procedure and Measures*

The participants accessed the online survey through a link or QR code provided. First, as a control measure, we asked them to indicate their momentary subjective vitality using a two-item subscale from a validated mood measure (Wilhelm & Schoebi, 2007). They responded to the statement "At this moment I feel" by means of two bipolar items ranging from 1 (*tired*) to 7 (*awake*) as well as from 1 (*full of energy*) to 7 (*no energy*). For data analysis, the "full of energy–no energy" item was recoded, with high values indicating high energetic arousal. The total vitality score was calculated as a mean score from both items (Cronbach's $\alpha = 0.87$). High total scores indicated high vitality.

Next, the participants were randomly assigned to either the low vitality ($n$ = 245) or the high vitality condition ($n$ = 242). Depending on the condition the participants were in, they were presented with a description of a person experiencing either high levels or low levels of vitality. In the low vitality condition, the participants were shown the responses of a fictional character who exhibited low vitality in the German state version of the Subjective Vitality Scale (SVS-G; Bertrams et al., 2020). For instance, in the accompanying prefilled questionnaire (Online Resource 1), the statement "I feel energetic right now" was marked as 1 (*does not apply at all*) for that person. Conversely, in the high vitality condition, this same statement received a rating of 7 (*applies exactly*) from the fictitious person. In sum, the response pattern presented in the high vitality condition was an exact mirror image of the response pattern in the low vitality condition (e.g., the response "2" for an item on a scale from 1–7 in the low vitality condition corresponded to a "5" for the same item in the high vitality condition). Whenever participants had to rate their fictitious character's presumed behavior or experience, the instructions and items from the original self-reported scales were adjusted slightly to make them applicable in the context of other-reported assessments (e.g., "I feel" was changed to "The described person feels").

As a manipulation-check, both groups rated their fictitious character's vitality with the same two bipolar items ($\alpha$ = 0.83; Wilhelm & Schoebi, 2007) with which they indicated their own vitality at the beginning. However, they were now explicitly instructed to rate not their own but the fictious character's subjective vitality.

Afterward, all participants rated their respective character's motivation to conserve energy. The assessment was performed using Blaise et al.'s (n.d.) German version of the Conservation of Human Energy Resources Index (CHERI-G). The instruction stated: "Please indicate how the person who filled in the [vitality] questionnaire feels at the moment." The participants then responded to the five CHERI-G items (e.g., "Right now, this person wants to

save their energy resources") on a six-point scale from 1 (*does not apply at all*) to 6 (*applies exactly*). The total score was calculated by the mean of the five items. Higher total scores indicated greater motivation to conserve energy resources. The scale showed excellent internal consistency ($\omega = 0.96$).

The participants were then told that the fictitious person had to solve five anagram tasks and could determine the level of difficulty from 1 (*very easy*) to 6 (*very hard*) on their own. The participants were then asked to indicate on a single item which level of difficulty they thought the person would choose. This measure—which has also been applied in the validation process of the motivation for cognition state scale (Blaise et al., 2021)—was to assess the cognitive effort that the participants would attribute to the fictitious person depending on the condition they were in. The higher the level that the participants believed the fictitious person would choose, the greater the cognitive motivation they attributed to that person.

Finally, the participants completed a second control measure, the six-item ($\omega = .93$) Implicit Theories About Willpower for Strenuous Mental Activities Scale (ITW-M; Job et al., 2010). We recoded the items so that high ITW-M scores corresponded to the belief that willpower is an unlimited resource, while low ITW-M scores suggested the implicit theory that willpower is exhaustible. Interindividual differences in willpower theories could influence how the fictional character's motivation to conserve energy was rated. For example, a person who is convinced that willpower is unlimited would not feel the need to recover from strenuous mental activities and would rate the fictional character's need to conserve energy reserves as low. The contrary may apply to a person who believes that willpower is a limited resource. The participants responded to each of the six items (e.g., "The described person's mental stamina fuels itself. Even after strenuous mental exertion, they can continue doing more of it") on a scale from 1 (*strongly agree*) to 6 (*strongly disagree*).

At the end of the questionnaire, the participants provided their demographic information and completed the seriousness check by Aust et al. (2013), as described above. After the survey, they were debriefed and thanked for their participation.

## Results and Discussion

### Covariates and Randomization Check

We checked if our two control measures (i.e., participants' implicit theories of willpower and their own subjective vitality) needed to be included as covariates in the main analyses. There were no significant differences regarding willpower theories between the low vitality condition ($M$ = 3.89, $SD$ = 0.93) and the high vitality condition ($M$ = 3.88, $SD$ = 1.00), according to Welch's independent $t$-test ($t$[481.90] = –0.07, $p$ = .94, bootstrapped 95% CI [–2.04; 1.92]). No significant differences were found either when comparing the participants' own subjective vitality from the low vitality condition ($M$ = 4.20, $SD$ = 1.50) to the subjective vitality of participants from the high vitality condition ($M$ = 3.94, $SD$ = 1.47): $t$[484.97] = 1.88, $p$ = .06, bootstrapped 95% CI [–0.14, 3.79]. As both variables did not reveal any significant group differences, we concluded that our randomization process had been successful and that the variables would not have to be included as covariates in the main analysis.

### Manipulation Check

As a manipulation check, we tested whether the fictious person's prefilled questionnaires presented for both conditions were perceived differently in terms of subjective vitality. This was indeed the case, as shown by the steep left- and right-skewed distributions of the vitality mean scores in both conditions (Online Resource 2). Since normality was clearly not given, to compare both groups' ratings, instead of the originally intended $t$-test, we

performed a Wilcoxon rank sum test with continuity correction.[1] The test statistic ($W$ = 2256.50, $p < .001$) indicated that the experimental vignette depicting a fictitious character high in subjective vitality was rated significantly higher in terms of subjective validity than the character low in subjective vitality. The effect size, calculated as a rank-biserial correlation coefficient ($r_{rb} = –.81$), can be considered as very high (Cohen, 1988; Fritz et al., 2012).

**Main Analysis: Energy Conservation Motivation and Cognitive Effort Motivation**

Next, we tested our two main hypotheses, that low vitality is attributed to high motivation to conserve energy and to low motivation to exert cognitive effort and that the opposite should be true for high vitality. Table 1 lists the relevant descriptive values of the dependent variables, distribution properties, and test statistics of the group comparisons. Because both variables (i.e., motivation to conserve energy and cognitive motivation) were not normally distributed (Online Resource 2), to compare both groups' ratings, we performed two Wilcoxon rank sum tests with continuity correction instead of the planned *t*-tests. We accounted for potential alpha inflation in both analyses by applying a Bonferroni adjusted significance level of $\alpha = .05 / 2 \text{ tests} = .025$.

The results showed that participants who were presented with a prefilled questionnaire from a fictitious person low in subjective vitality rated this person's motivation to conserve energy as significantly higher ($W = 56220$, $p < .001$, $r_{rb} = .79$), and their cognitive motivation significantly lower ($W = 4459.50$, $p < .001$, $r_{rb} = –.75$), than the participants who had been

[1] Opting for the Wilcoxon rank sum test, instead of the *t*-test, necessitated the inclusion of an additional 10 participants to effectively detect a medium-sized effect of $d = 0.40$ with a power of $1-\beta = .80$, resulting in a sample size of 252 subjects (Faul et al., 2007). Our study comfortably met this requirement, with a sample size of 487 participants.

given a questionnaire of a person high in subjective vitality. These results are in line with the schema model of self-control in terms of the mental representations that are a necessary precursor of the proposed mechanism underlying self-control failure. That is, the state of decreased subjective vitality (i.e., perceiving low energy or high fatigue) is mentally associated with being highly motivated to conserve energy reserves and having a low motivation to exert effort.

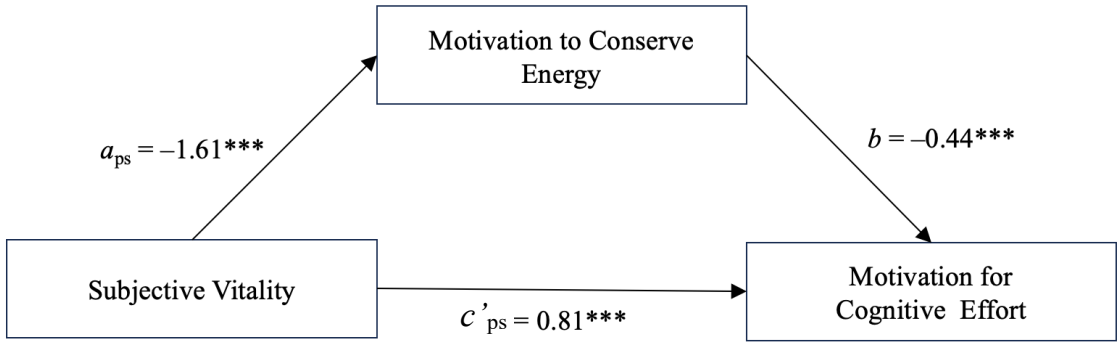
**Secondary Analysis**

We then tested the hypothesis from the schema model of self-control—that is, people have a mental representation of an activated decreased vitality schema that induces motivation to conserve energy, which in turn results in reduced effort (Bertrams, 2020). To test this hypothesis, we conducted a mediation analysis (see Fig. 2) using Hayes's (2022) PROCESS v. 4.3.1 function in R Studio. The results showed that the fictious person's motivation to conserve energy mediated the relationship between their rated subjective vitality and rated motivation for cognitive effort ($[ab]_{ps}$[2] = 0.70, 95% $CI_{\text{indirect effect}}$ [0.51, 0.91]; bias-corrected bootstrapping with 5,000 resamples). This finding suggests that individuals either consciously or preconsciously have an idea that it is necessary or advantageous to use sparingly their energy reserves when vitality is low. Finally, the thoughtful use of energy reserves also means that individuals must reduce their cognitive efforts, which is reflected by relatively low motivation for cognitive effort.

[2] $(ab)_{ps}$ stands for the partially standardized indirect effect, which corresponds to the product of ($a$) the partially standardized effect of the dichotomous group variable (X) on the mediator energy conservation (M) and ($b$) the completely standardized effect of M on cognitive motivation (Y), controlling for X (Hayes, 2022).

**Fig. 2**

*Mediation of the Direct Effect of Subjective Vitality on Cognitive Motivation via the Mediator Motivation to Conserve Energy (Study 1)*




*Note*. Depicted are the standardized beta weights ($b$) and partially standardized beta weights ($a_{ps}$, $c'_{ps}$). $N = 487$. ***$p < .001$.

## Study 2

In Study 2, we aimed to replicate the findings of Study 1 under a slightly different premise. In a mixed between-within-subject design, all participants first read a story about a character who expressed no specific vital cues or other emotional state. Afterward, per random assignment, they read a story about a character who experienced either low or high vitality and rated the character's motivation to conserve energy as well as subjective vitality and cognitive motivation.

### Method

#### *Ethical Requirements and Open Science*

We obtained ethical approval and informed consent in the same way as for Study 1. Study 2 was pre-registered at AsPredicted.org (https://aspredicted.org/blind.php?x=DB2_8NW– identifier #147506) before the data were collected. The raw data supporting the findings of this this study can be accessed at https://researchbox.org/.

***Participants***

The sample were recruited online using the *Clickworker* recruitment platform (https://www.clickworker.de). Participants received monetary compensation of €1.75 for participating in the study.

We conducted a power analysis (G∗Power 3.1; Faul et al., 2007) to determine the necessary sample size for detecting a medium-sized effect with sufficient statistical power (input parameters: power analysis: analysis of variance, repeated measures, within-between interaction; input parameters: $f = 0.25$, Bonferroni adjusted $\alpha = .025$, $1-\beta = .80$; number of groups = 2; number of measurements = 2; correlation among repeated measures = 0; non-sphericity correction $\varepsilon = 1$). The analysis revealed that a minimum sample size of 80 participants was required for the study. With 487 participants having completed the online survey, we ensured a well-powered study design.

We excluded those who stated in preregistration that they did not have sufficient proficiency in German ($n = 4$), who presented $z$-values ± 3.29 (Tabachnick & Fidell, 2019) on total scores of the central variables ($n = 21$), or who did not fill out the ITW-M questionnaire as instructed ($n = 10$). To clarify the latter, in the ITW-M, participants were asked to write a number between 1 and 6 in the box next to each item, indicating how strongly they agreed or disagreed with the statement. We excluded those who entered numbers outside the range of 1–6. As the survey was administered online, we also implemented a data integrity check in line with the guidance provided by Meade and Craig (2012). The participants were asked to indicate whether we should use their data in our subsequent analyses (*yes* or *no*). A total of four individuals acknowledged that they had not seriously engaged with the survey. One participant also noted that he had missed the transition from story 1 to story 2 and that all his answers related to the first story. Even if this was not preregistered, it seemed reasonable to us to remove this person from the dataset. Taken together, a combined total of 38 participants

were excluded from our analysis, resulting in a final sample size of 449 participants (41.2% female; $M_{age}$ = 40.66 years, *SD* = 12.06). The participants included workers (74.8%), students (4.7%), students with part-time jobs (7.8%), and "other" (12.7%). The majority reported having a university degree (47.7%), while 25.3% had a high school degree and 17.1% had a general certificate of secondary education.

***Procedure and Measures***

As part of a baseline measurement, all participants first read a neutral description of an office worker sitting at a desk at work (story 1, Online Resource 3). The gender was not mentioned, and the description did not contain any adjectives or references that could be used to infer any emotional state or mood. After reading the story, the participants rated this character's subjective vitality using the five-item SVS-G (Bertrams et al., 2020) on a scale from 1 (*does not apply at all*) to 7 (*applies exactly*). The scale showed excellent internal consistency (ω = .99). As in Study 1, the instructions and items from self-report scales were adapted for other-report assessments. This also applied to the measures described in the following.

The participants were then randomly assigned to two conditions. In the high subjective vitality condition (*n = 227*), participants read a story (story 2a, Online Resource 3) similar to that during the baseline measurement, except that it was enriched with vitality-typical adjectives taken from validated vitality questionnaires (Bertrams et al., 2020; Goldbeck et al., 2019). Participants in the low subjective vitality condition (*n = 222*), on the other hand, received the fictitious person's description (story 2b, Online Resource 3) in a way that differed from the vitality condition only in the sense that it included words suggesting low subjective vitality or high fatigue. Where necessary, appropriate synonyms and antonyms were taken from linguistic lexicons (Agricola & Agricola, 1992; Bulitta & Bulitta, 2002,

Müller & Ebner, 2020) so that the subjective vitality scale items could be meaningfully embedded in our experimental stories.

For each story, the participants rated the fictional character's motivation to conserve energy and motivation for cognitive effort. To measure the motivation to conserve energy, we used the CHERI-G (ω = .99), as in Study 1. The motivation for cognitive effort was assessed using Blaise et al.'s (2021) Motivation for Cognitive Effort State Scale (MFC; ω = .97). The participants rated the fictitious character's momentary motivation for cognitive effort with 10 items (e.g., "Right now, the described person prefers complex to simple problems") on a seven-point scale from 1 (*does not apply at all*) to 7 (*applies exactly*).

As in Study 1, as a control measure, we also assessed the participants' implicit theories of willpower (Job et al., 2010) with the ITW-M (ω = .93). Lastly, participants provided demographic details and completed the self-report attention check, as described above (Meade & Craig, 2012).

## Results and Discussion

### Robustness of the Analysis

To account for violations of non-normality (Online Resource 4) and homogeneity of variances, we took a couple of precautions. First, all the mixed between-within ANOVAS reported in the following were additionally supplemented with robust methods (i.e., bootstrapping and mean-trimming) using the WRS2 package in R (Mair & Wilcox, 2020; Mair et al., 2023), which indicated the robustness of the present results. Second, for post-hoc testing of the main effects, we used Welch's robust two-sample *t*-test for between-groups comparisons and applied bias-corrected and accelerated bootstrapping when running both between and within comparisons. All reported *t*-test results in the following sections were repeated using nonparametric Wilcoxon signed rank (for paired samples) and rank sum (for

independent samples) tests to ensure the reliability of the results. Again, our results remained unchanged, regardless of the method we applied.

**Randomization Check and Control Variables**

To check whether our randomization procedure had been successful and to rule out that a potential covariate could have biased the stories' ratings, we compared participants' implicit theories about willpower (ITW-M) in both conditions, as we did in Study 1. The ITW-M mean scores in the low-vitality condition ($M$ = 3.26, $SD$ = 0.87) did not significantly differ from those of the high vitality condition ($M$ = 3.29, $SD$ = 0.92; $t$[446.29] = –0.38, $p$ = .71; bootstrapped 95% CI [–2.38, 1.56]). These results suggest that the randomization procedure had been successful and that ITW-M scores did not need to be included as covariates in the main analyses.

In the baseline measure, where the neutral story was identical for both groups, no significant mean differences were found between the two conditions regarding their perceived motivation to conserve energy ($t$[446.75] = –0.40, $p$ = .69, bootstrapped 95% CI [–2.32, 1.57], $d$ = –0.04) and their perceived motivation for cognitive effort ($t$[446.83] = –1.21, $p$ = .23, bootstrapped 95% CI [–3.27, 0.73], $d$ = – 0.11). Hence, it can be concluded that the participants perceived the neutral story consistently across both groups, further supporting the effectiveness of the randomization process.

**Manipulation Check**

For our experimental manipulation, we wrote three stories describing fictitious characters experiencing neutral (story 1), high (story 2a), and low (story 2b) states of vitality. To check whether the stories had actually been perceived differently by the participants in terms of the fictious character's subjective vitality, we conducted a 2 × 2 mixed between-within ANOVA with two experimental conditions (high subjective vitality vs. low subjective vitality) and two repeated measures (story 1 vs. story 2). The descriptive statistics can be

found in Table 2. The results revealed significant effects for the between factor (experimental condition; $F[1, 447] = 820.89$, $p < .001$, $\eta_p^2 = 0.65$), the within factor (repeated measures; $F[1, 447] = 4.33$, $p = .04$, $\eta_p^2 = 0.01$), and the interaction term ($F[1, 447] = 1090.95$, $p < .001$, $\eta_p^2 = 0.71$. Hence, the three stories validly depicted the intended states of subjective vitality in the intended manner.

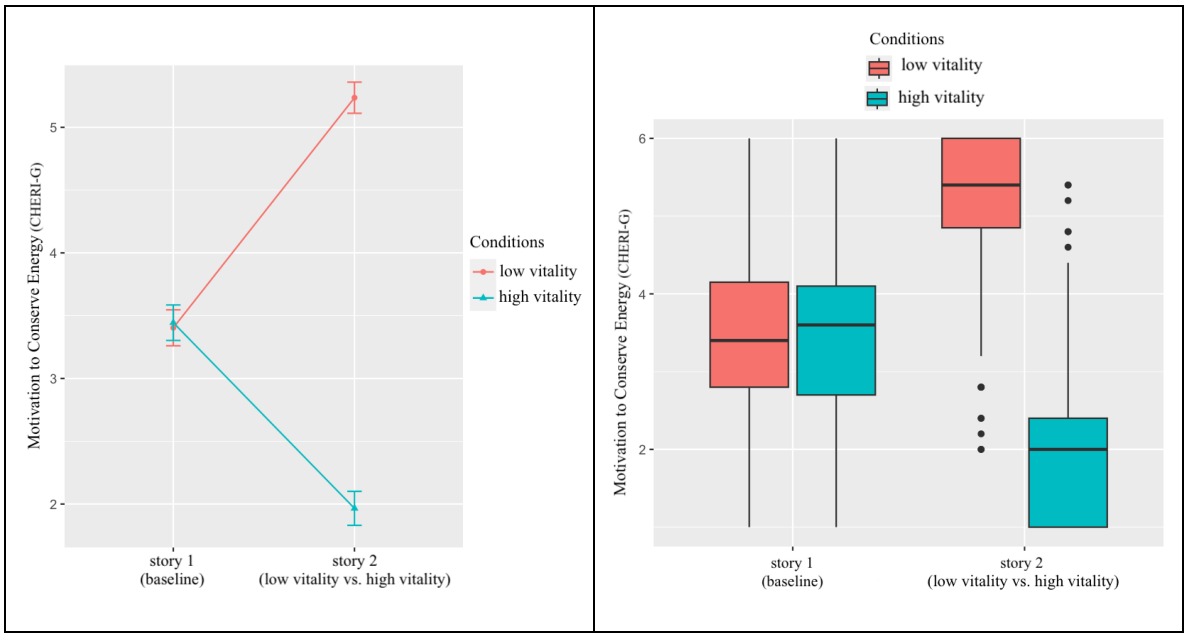
**Main Analysis**

To test our main hypotheses (i.e., low-vital individuals are attributed a higher motivation to conserve energy and a lower cognitive motivation compared to high-vital individuals), we conducted two mixed between-within-subjects ANOVAs with a Bonferroni adjusted significance level of $\alpha = .025$.

Regarding the dependent variable "motivation to conserve energy", the results of the 2 (experimental condition: high subjective vitality condition vs. low subjective vitality condition) × 2 (repeated measure: first story vs. second story) ANOVA revealed that there were highly significant effects for the between factor (experimental condition; $F[1, 447] = 445.65$, $p < .001$, $\eta_p^2 = 0.50$), the within factor ($F[1, 447] = 8.45$, $p = .004$, $\eta_p^2 = 0.02$), and the interaction term ($F[1, 447] = 739.24$, $p < .001$, $\eta_p^2 = 0.62$). This finding (see also Fig. 3) and the respective means (Table 2) suggest that, compared to a neutral baseline story, the participants had a mental representation of individuals low in subjective vitality experiencing a higher motivation to conserve energy compared to individuals high in subjective vitality.

**Fig. 3**

*Results of the Mixed 2 Condition (Low vs. High Subjective Vitality) × 2 Time (Neutral Story 1 vs. Story 2) ANOVA on Motivation to Conserve Energy (CHERI-G)*




To interpret the interaction effect, we compared the means (see Table 2) using a row of post-hoc *t*-tests with a Bonferroni adjusted significance level[3] of α = .008. In the high subjective vitality condition, perceived motivation to conserve energy in the second story was rated significantly lower than in the first story ($t$[226] = 18.94, $p$ < .001, bootstrapped 95% CI [16.58, 21.39], $d_z$ = 1.40). In the low subjective vitality condition, perceived motivation to conserve energy in the second story was rated significantly higher than in the first story ($t$[221] = –19.54, $p$ < .001, bootstrapped 95% CI [–21.99, –16.82], $d_z$ = –1.81). Perceived motivation to conserve energy in the second story was rated higher in the low subjective

[3] To address potential alpha-error inflation in our post-hoc *t*-tests, including the central dependent variables CHERI-G and MFC, we applied a correction for multiple comparisons. In total, we conducted four within-group and two between-group comparisons. Therefore, we set the threshold for statistical significance at α = .05 / 6 tests = .008.

vitality condition than in high subjective vitality condition ($t$[444.41] = 35.12, $p$ < .001, bootstrapped 95% CI [30.68, 39.67], $d$ = 3.31).

Finally, we tested whether the degree of cognitive motivation that participants would attribute to a person described as highly vital increased compared to the vitality attributed to a person described as low in vitality after reading a neutral story. Another 2 × 2 mixed between-within-subject ANOVA was conducted, with motivation for effortful cognition as the dependent variable. The effects were significant for the between factor (experimental condition; $F$[1, 447] = 751.22, $p$ < .001, $\eta_p^2$ = 0.63), the within factor (repeated measures; $F$[1, 447] = 45.80, $p$ < .001, $\eta_p^2$ = 0.09), and the interaction term ($F$[1, 447] = 802.39, $p$ < .001, $\eta_p^2$ = 0.64). A graphical illustration of these results is shown in the supplemental material (Online Resource 5).

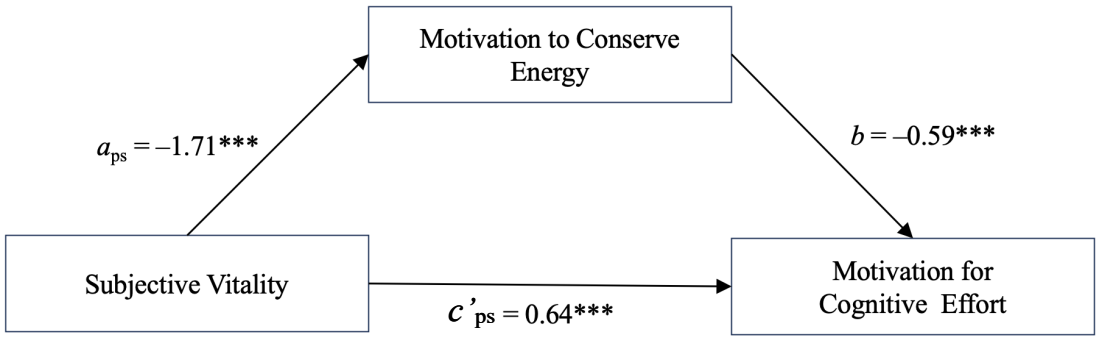
To interpret the interaction effect, means (see Table 2) were compared post hoc using a row of $t$-tests with a Bonferroni adjusted significance level of α = .008. In the high subjective vitality condition, perceived motivation for cognitive effort in the second story was rated significantly lower than in the first story ($t$[226] = –15.23, $p$ < .001, bootstrapped 95% CI [–17.79, –12.61], $d_z$ = –1.53). In the low subjective vitality condition, perceived motivation for cognitive effort in the second story was rated significantly higher than in the first story ($t$[221] = 24.85, $p$ < .001, bootstrapped 95% CI [20.94, 28.35], $d_z$ = 2.00). Perceived motivation for cognitive effort in the second story was rated lower in the low-subjective vitality condition than in high subjective vitality condition ($t$[422.68] = –31.37, $p$ < .001, bootstrapped 95% CI [–34.64, –28.15], $d$ = 2.97). Consistent with the findings of Study 1, the results provide evidence for the presence of mentally represented associations between subjective vitality, energy conservation motivation, and cognitive motivation—all in the predicted directions as specified in the preregistration.

### Secondary Analysis

To replicate the findings from Study 1, we conducted a mediation analysis (see Fig. 4) to explore whether the relationship between the fictitious characters' rated subjective vitality and their rated motivation for cognitive effort could be indirectly explained by their motivation to conserve energy. In line with our previous findings, the indirect effect was significant ($[ab]_{ps} = 1.01$, bootstrapped 95% $CI_{\text{indirect effect}}$ [0.85, 1.19]). Furthermore, the direct effect ($c' = 0.64$) was significant ($p < .001$), indicating that motivation to conserve energy partially mediated the relationship between subjective vitality and cognitive motivation.

**Fig. 4**

Mediation of the Direct Effect of Vitality on Cognitive Motivation via the Mediator Motivation to Conserve Energy (Study 1)




*Note*. Depicted are the standardized beta weights ($b$) and partially standardized beta weights ($a_{ps}$, $c'_{ps}$). $N = 449$. ***$p < .001$.

## General Discussion

In two randomized control studies with varied samples, designs, and measures, we investigated how individuals mentally link subjective vitality to motivation to conserve energy and motivation for cognitive effort. We assumed that the participants held a mental representation where low vitality, as opposed to high vitality, is associated with increased motivation to conserve energy and decreased cognitive motivation, as posited by the schema

model of self-control (Bertrams, 2020). The participants were shown either prefilled vitality questionnaires of a fictitious character (Study 1) or short stories describing office workers (Study 2) experimentally varying in vitality levels. Based on these vignettes, the participants rated the characters' motivation to conserve energy and motivation for cognitive effort.

Across both studies, the results consistently confirmed our hypotheses. The participants associated characters expressing low vitality with a higher need to conserve energy and a lower motivation to exert cognitive effort than those expressing high vitality. With regard to the schema model (Bertrams, 2020), there seems to be an inherent concept within the human mind that signals the need for energy conservation as a function of perceived vitality. This mental representation also includes decreased motivation for cognitive effort once a cognitive schema of low vitality is activated. The interpretation of these results suggests that cognitive exertion is perceived as a substantial threat to an individual's energy reserves, thereby conflicting with their momentary need for energy conservation. Preliminary evidence supporting this assumption came from our mediation analysis, which showed that the mental association between feeling vital and being motivated for cognitive effort is indeed partially mediated by an urge for energy resource conservation. From a bioeconomic perspective, it makes sense for individuals to minimize effort during periods of low energy. This can be metaphorically described as switching to a functional energy-conservation mode, where energy resources are carefully allocated. Such an approach not only encourages cautious expenditure but also potentially allows for the restoration of one's energy levels to some extent, similar to recharging a battery (Weigelt et al., 2022). The activated decreased-vitality schema can therefore serve as a protective mechanism. Since it is key for a cognitive-motivational process, it may prevent individuals from complete energy exhaustion and allow them to dynamically respond to unforeseen circumstances that require substantial energy output (Gendolla & Richter, 2010). Hence, as the motivation to conserve energy resources

becomes more predominant, individuals invest less effort, making strenuous and energy-consuming self-regulation increasingly unlikely to succeed (Bertrams, 2020).

While we successfully established a significant foundation in this study for the investigation of underlying mental representations and their associations, further research is needed to gather evidence at the level of actual behavior that speaks for the relationships postulated in the model—and not just in relation to a small part of the model but with regard to the entire causal chain. When examining real behavior, however, the effect sizes are likely to be much smaller. While our experimental manipulations with stories concerning fictitious characters evidently suggested the activation of the decreased-vitality schema to the study participants in extreme and opposite ways in both conditions, less pronounced emotional states will likely be observed when studying real behavior in everyday life. Future experimental studies that seek to provide evidence for causality should take this limitation into account. To investigate the schema model of self-control at the behavioral level, reliable and valid methods will be required to manipulate study participants' own subjective vitality.

## Disclosure Statement

The authors report there are no competing interests to declare.

## Data Availability Statement

The raw data that support the findings of this study are openly available at https://researchbox.org.

**References**


1. Agricola, C., & Agricola, E. (1992). *Duden Wörter und Gegenwörter: Wörterbuch der sprachlichen Gegensätze.* Dudenverlag.
2. Aust, F., Diedenhofen, B., Ullrich, S., & Musch, J. (2013). Seriousness checks are useful to improve data validity in online research. *Behavior Research Methods*, *45*, 527–535. https://doi.org/10.3758/s13428-012-0265-2
3. Baumeister, R. F., Gailliot, M., DeWall, C. N., & Oaten, M. (2006). Selfregulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality*, *74*, 1773−1802. https://doi.org/10.1111/j.1467-6494.2006.00428.x
4. Baumeister, R. F., & Vohs, K. D. (2016). Strength model of self-regulation as limited resource: assessment, controversies, update. In J. M. Olson & M. P. Zanna (Eds.), *Advances in Experimental Social Psychology* (pp. 67–127). Academic Press. https://doi.org/10.1016/bs.aesp.2016.04.001
5. Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science*, *16*, 351–355. https://doi.org/10.1111/j.1467-8721.2007.00534.x
6. Bertrams, A. (2020). A schema-activation approach to failure and success in self-control. *Frontiers in Psychology*, *11*, 2256. https://doi.org/10.3389/fpsyg.2020.02256
7. Bertrams, A. (2021). The cognitive association between effortful self-control and decreased vitality. *Frontiers in Psychology*, *12*, 631914. https://doi.org/10.3389/fpsyg.2021.631914
8. Bertrams, A., Dyllick, T. H., Englert, C., & Krispenz, A. (2020). German adaptation of the subjective vitality scales (SVS-G). *Open Psychology*, *2*, 57–75. https://doi.org/10.1515/psych-2020-0005

9. Blaise, M., Marksteiner, T., Krispenz, A., & Bertrams, A. (2021). Measuring motivation for cognitive effort as state. *Frontiers in Psychology*, *5842*. https://doi.org/10.3389/fpsyg.2021.785094

10. Brysbaert, M. (2019). How many participants do we have to include in properly powered experiments? A tutorial of power analysis with reference tables. *Journal of Cognition, 2,* 1–38. https://doi.org/10.5334/joc.72

11. Bulitta, E., & Bulitta, H. (2003). *Wörterbuch der Synonyme und Antonyme: sinn-und sachverwandte Wörter und Begriffe sowie deren Gegenteil und Bedeutungsvarianten.* Fischer.

12. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum Associates.

13. De Ridder, D. T., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2012). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality and Social Psychology Review*, *16*, 76–99. https://doi.org/10.1177/10888683114187

14. Duckworth, A. L., Taxer, J. L., Eskreis-Winkler, L., Galla, B. M., & Gross, J. J. (2019). Self-control and academic achievement. *Annual Review of Psychology*, *70*, 373–399. https://doi.org/10.1146/annurev- psych- 010418- 103230

15. Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. https://doi.org/10.3758/bf0319314

16. Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, *141*, 2–18. https://doi.org/10.1037/a0024338

17. Gainsburg, I., & Lee Cunningham, J. (2023). Compassion fatigue as a self-fulfilling prophecy: Believing compassion is limited increases fatigue and decreases compassion. *Psychological Science*, *34*, 1206–1219. https://doi.org/10.1177/0956797623119453

18. Gendolla, G. H., & Richter, M. (2010). Effort mobilization when the self is involved: Some lessons from the cardiovascular system. *Review of General Psychology*, *14*, 212–226. https://doi.org/10.1037/a00197

19. Goldbeck, F., Hautzinger, M., & Wolkenstein, L. (2019). Validation of the German version of the subjective vitality scale-a cross-sectional study and a randomized controlled trial. *Journal of Well-Being Assessment*, *3*, 17–37. https://doi.org/10.1007/s41543-019-00019-8

20. Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford publications.

21. Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives on Psychological Science*, *7*, 450–463. https://doi.org/10.1177/1745691612454134

22. Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion – Is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*, 1686–1693. https://doi.org/10.1177/0956797610384745

23. Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences*, *36*, 661–679. https://doi.org/10.1017/S0140525X1200319

24. Mair, P., & Wilcox, R. (2020). Robust statistical Methods in R using the WRS2 package. *Behavior Research Methods, 52,* 464–488.

25. Mair, P., Wilcox, R., & Patil, I. (2023). *WRS2: A Collection of robust statistical methods* (Version 1.1-5) [Software]. Available from https://CRAN.R-project.org/package=WRS2

26. Meade, A. W., & Craig, S. B. (2012). Identifying careless responses in survey data. *Psychological Methods*, *17*, 437–455. https://doi.org/10.1037/a0028085

27. Mitchell. P. G. & Tetlock, P. E. (2020). Stretching the limits of science: Was the implicit-bias debate social psychology's bridge too far? In J. A. Krosnick, T. H. Stark, & A. L. Scott (Eds.), *Implicit bias theory and research*. Cambridge University Press.

28. Müller, W., & Ebner, J. (2020). *Das Gegenwort-Wörterbuch: ein Kontrastwörterbuch mit Gebrauchshinweisen*. Walter de Gruyter.

29. Muraven, M., & Slessareva, E. (2003). Mechanisms of self-control failure: Motivation and limited resources. *Personality and Social Psychology Bulletin*, *29*, 894–906. https://doi.org/10.1177/0146167203029007008

30. Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, *2*(2), 702–717. https://doi.org/10. 1111/j.1751-9004.2008.00098.x

31. Shalev, I. (2014). Implicit energy loss: Embodied dryness cues influence vitality and depletion. *Journal of Consumer Psychology*, *24*, 260–270. https://doi.org/10.1016/j.jcps.2013.09.011

32. Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th Ed.). Pearson.

33. Tangney, J., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72*, 271–324. https://doi.org/10.1111/j.0022-3506.2004.00263.x

34. Weigelt, O., Gierer, P., Prem, R., Fellmann, M., Lambusch, F., Siestrup, K., Marcus, B., Franke, T., Tsantidis, S., Golla, M., Wyss, C., & Blume, J. (2022). Time to recharge batteries–development and validation of a pictorial scale of human energy. *European*

*Journal of Work and Organizational Psychology*, *31*, 781–798. https://doi.org/10.1080/1359432X.2022.2050218

35. Wilhelm, P., & Schoebi, D. (2007). Assessing mood in daily life: Structural validity, sensitivity to change, and reliability of a short-scale to measure three basic dimensions of mood. *European Journal of Psychological Assessment, 23*, 258–267. https://doi.org/10.1027/1015-5759.23.4.258

**Table 1**

*Mean Ranks, Distribution Properties, and Test Statistics of the Group Comparisons in Study 1*

| | Low vitality condition ($n$ =245) | | High vitality condition ($n$ = 242) | | Wilcoxon rank sum test | | |
|---|---|---|---|---|---|---|---|
| | $M_{ranks}$ | $Z_{skewness}$ | $M_{ranks}$ | $Z_{skewness}$ | $W$ | $Z_W$ | $r_{rb}$ |
| Vitality (manipulation check) | 132.21 | 6.86 | 357.18 | –10.21 | 2256.5 | –17.90 | –0.81 |
| Motivation to conserve energy | 352.47 | – 8.18 | 134.19 | 10.96 | 56220 | 17.35 | 0.79 |
| Motivation for cognitive effort | 141.20 | 8.46 | 348.07 | –5.57 | 4459.5 | –16.56 | –0.75 |

*Note.* $N$ = 487. $Z_{skewness}$ = $z$-value of the skewness, $W$ = Wilcoxon test statistic (all $p < .001$, two sided), $Z_W$ = $z$-value of the Wilcoxon test statistic, $r_{rb}$ = rank biserial correlation coefficient.

**Table 2**

*Descriptive Statistics for the Main Variables in Study 2*

| | Low subjective vitality condition ($n$ = 222) | | | High subjective vitality condition ($n$ = 227) | | |
|---|---|---|---|---|---|---|
| | SVS-G | CHERI-G | MFC | SVS-G | CHERI-G | MFC |
| | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) |
| **First Story:** neutral description | 3.67 (1.20) | 3.40 (1.08) | 4.04 (0.51) | 3.65 (1.28) | 3.44 (1.08) | 4.10 (0.51) |
| **Second Story:** low subjective vitality vs. high subjective vitality | 1.57 (1.09) | 5.24 (0.94) | 2.28 (1.08) | 6.03 (0.69) | 1.97 (1.03) | 5.18 (0.86) |

*Note.* $N$ = 449. All $p < .001$, two sided. SVS-G = Subjective Vitality Scales (German), CHERI-G = Conservation of Human Resources Index (German), MFC = motivation for cognitive effort.

## Online Resource 1

*Pre-filled Vitality Questionnaires (SVS-G) of Fictitious Characters Shown to Participants in Study 1*

A Low Vitality Condition

Bitte geben Sie für jede der folgenden Aussagen an, wie sehr sie **jetzt, d.h. in diesem Moment**, auf Sie zutrifft.

**1. In diesem Moment fühle ich mich lebendig und vital.**

| ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**2. Gerade fühle ich mich so lebendig, dass ich platzen könnte.**

| ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**3. Ich habe im Moment Energie und Lebensfreude.**

| ☒ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**4. In diesem Moment fühle ich mich aufmerksam und wach.**

| ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**5. Ich fühle mich gerade energiegeladen.**

| ☒ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

B High Vitality Condition

Bitte geben Sie für jede der folgenden Aussagen an, wie sehr sie **jetzt, d.h. in diesem Moment**, auf Sie zutrifft.

**1. In diesem Moment fühle ich mich lebendig und vital.**

| ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**2. Gerade fühle ich mich so lebendig, dass ich platzen könnte.**

| ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**3. Ich habe im Moment Energie und Lebensfreude.**

| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**4. In diesem Moment fühle ich mich aufmerksam und wach.**

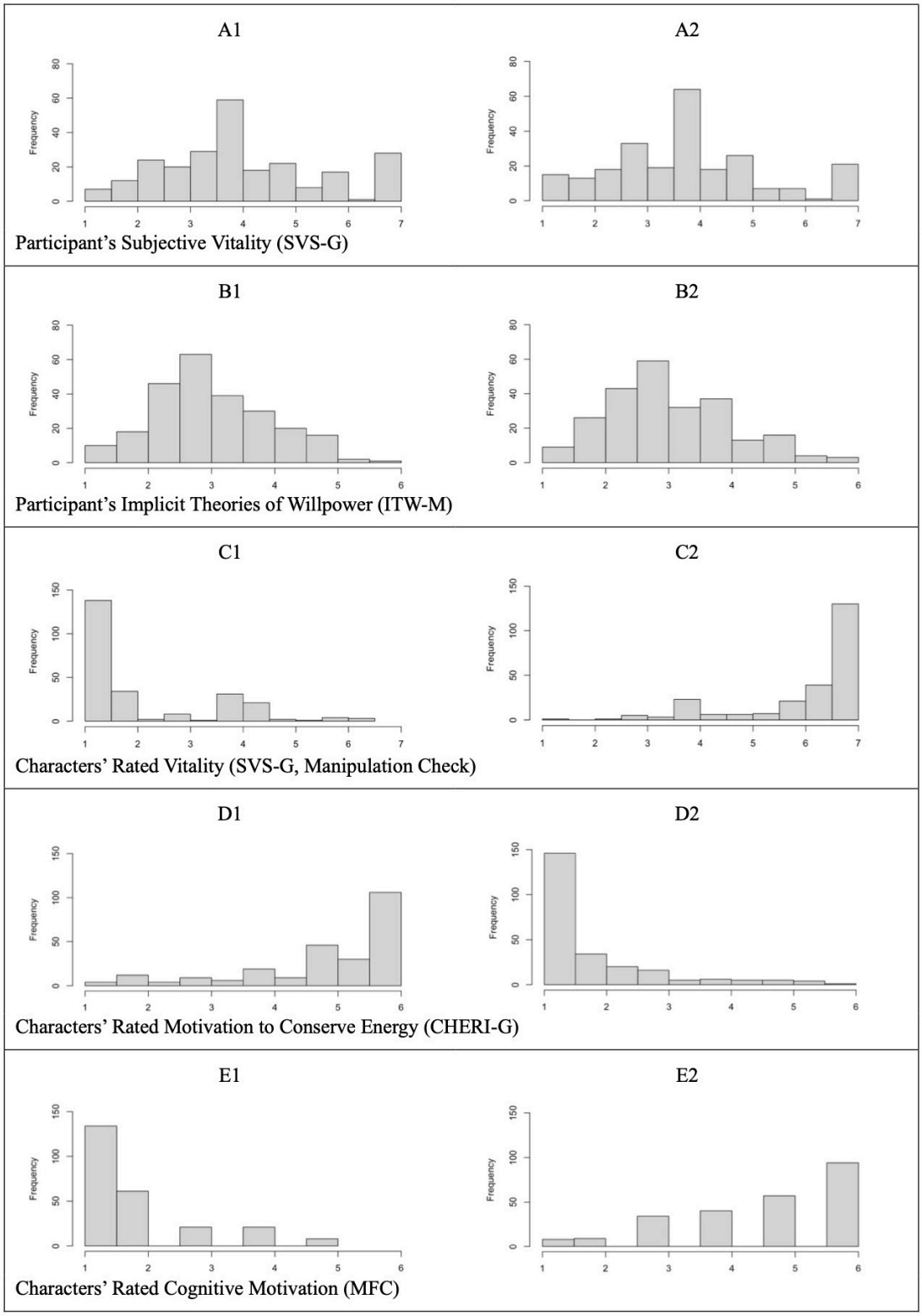
| ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**5. Ich fühle mich gerade energiegeladen.**

| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| trifft gar nicht zu | | | trifft etwas zu | | | trifft sehr zu |

**Online Resource 2**

*Distributions of Mean Scores in the Low Vitality Condition (left, Fig. A1–E1) and the High Vitality Condition (right, Fig. A2–E2) in Study 1.*



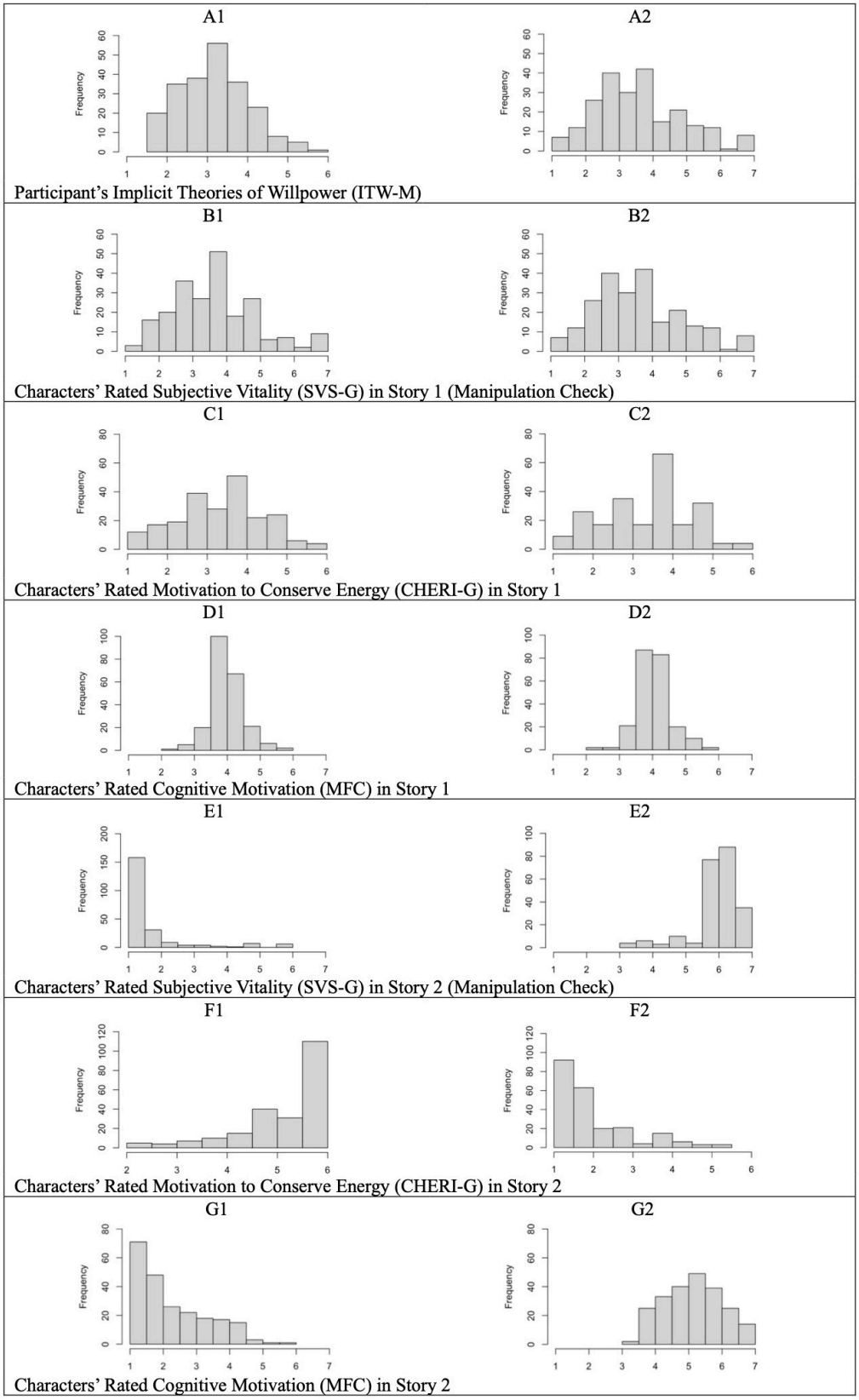
## Online Resource 3

*Experimental Stories in Study 2*

| **Story 1: Neutral vignette (baseline)**<br>German | **Story 1: Neutral vignette (baseline)**<br>English translation (with DeepL Pro) |
|---|---|
| Es ist Dienstagmorgen. | It's Tuesday morning. |
| Eine Person sitzt auf ihrem Bürostuhl. | A person is sitting in their office chair. |
| Sie wirft einen Blick aus dem Fenster. | They look out of the window. |
| Sie fühlt sich gerade gewöhnlich, so wie an jedem anderen normalen Tag auch. | They are feeling ordinary, just like any other normal day. |
| Kurze Zeit später wendet sie sich wieder ihrem Schreibtisch zu und setzt ihre Arbeit fort. | A short time later, they turn back to their desk and continue their work. |
| Sie bearbeitet ihre Kundendossiers. | They work on their customer dossiers. |
| **Story 2a: High vitality condition**<br>German | **Story 2a: High vitality condition**<br>English translation (with DeepL Pro) |
| Es ist Dienstagmorgen. | It's Tuesday morning. |
| Eine Person sitzt fit und munter auf ihrem Bürostuhl. | A person is sitting on their office chair, fit and alert. |
| Total ausgeruht wirft sie einen Blick aus dem Fenster. | Totally rested, they look out of the window. |
| Sie fühlt sich gerade äusserst lebendig und vital – voller Energie! | They feel extremely lively and vital—full of energy! |
| Kurze Zeit später wendet sie sich wieder ihrem Schreibtisch zu und setzt mit vollem Elan ihre Arbeit fort. | A short time later, they turn back to their desk and continue their work with full vigor. |
| Hochkonzentriert bearbeitet sie ihre Kundendossiers. | They work on their customer dossiers with deep concentration. |
| **Story 2b: Low vitality condition**<br>German | **Story 2b: Low vitality condition**<br>English translation (with DeepL Pro) |
| Es ist Dienstagmorgen. | It's Tuesday morning. |
| Eine Person sitzt schlapp und müde auf ihrem Bürostuhl. | A person sits limp and tired on their office chair. |
| Total erschöpft wirft sie einen Blick aus dem Fenster. | Totally exhausted, they glance out of the window. |
| Sie fühlt sich gerade überhaupt nicht lebendig und vital – komplett ohne Energie! | They don't feel alive and vital at all—completely without energy! |
| Kurze Zeit später wendet sie sich wieder ihrem Schreibtisch zu und setzt ohne jeglichen Elan ihre Arbeit fort. | A short time later, they turn back to their desk and continues their work without any energy. |
| Völlig unkonzentriert bearbeitet sie ihre Kundendossiers. | They work on their customer dossiers with a complete lack of concentration. |

**Online Resource 4**

*Distributions of Mean Scores in the Low Vitality Condition (left, Fig. A1–G1) and the High Vitality Condition (right, Fig. A2–G2) in Study 2.*



**Online Resource 5**

*Results of the Mixed 2 Condition (Low vs. High Subjective Vitality) × 2 Time (Neutral Story 1 vs. Story 2) ANOVA on Motivation to Conserve Energy (CHERI-G)*