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A dual-process model of early career researchers' well-being: Satisfaction and frustration of basic psychological needs as central mechanism

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Abstract
Early-career researchers are simultaneously subject to a work environment that offers academic freedom but also requires juggling teaching, research, and administration, which can be particularly challenging for this population. As such, higher education systems provide both resources that could foster well-being and demands that could enhance feelings of strain. To further understand these factors, we synthesize central tenets of job-demands-resources-models and self-determination theory into a dual-process model of early-career researchers' well-being. We argue that the needs for autonomy, competence, and relatedness are central to psychological functioning in academia. Furthermore, we view need satisfaction as a key resource fostering job satisfaction and need frustration as a central demand contributing to work strain. We investigated these dual processes in a sample of 367 German early-career researchers. In doing so, we used bi-factor structural equation modeling to address shared and unique associations of the three needs with the investigated criteria simultaneously. The sampled early-career researchers reported high job satisfaction alongside moderate work strain. Need satisfaction was a stronger predictor for satisfaction with work tasks, while need frustration was more strongly tied to work strain. Our findings underscore the utility of self-determination theory in developing dual process models of well-being and highlight the relevance of such models for understanding the psychological functioning of academic staff.

Keywords Early career researchers · Work strain · Well-being · Need satisfaction · Need frustration · Dual process models

The work of researchers is often marked by a high degree of autonomy, allowing them to pursue their own interests. However, their daily tasks are fragmented across teaching,

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research, funding acquisition, and administration. As a result, academia imposes multiple demands that are difficult to balance. This is likely especially true for untenured early-career researchers, who must juggle professional and personal responsibilities amid uncertain academic career prospects (Jackman et al., 2022; van der Weijden & Teelken, 2023). These challenges affect not only work–life balance but also *work–work balance*, meaning the capacity to manage competing professional demands (Griffin, 2022). Prior research has used job-demands-resources models to explain factors driving researchers' work strain and job satisfaction (e.g., Han et al., 2020; Mudrak et al., 2018). While job-demands-resources models effectively capture the coexistence of well-being and ill-being patterns, they risk tautology by defining demands and resources based on whether they positively or negatively relate to outcomes rather than grounding these classifications in underlying psychological mechanisms. To address this, we integrate Self-determination theory (Ryan & Deci, 2017) into the job-demands-resources framework, offering greater conceptual clarity. We propose that satisfaction of the basic psychological needs for autonomy, competence, and relatedness enhances job satisfaction, while their frustration contributes to work strain in academic staff. We test these processes empirically, while also further exploring whether individual needs differ in their relative importance for explaining well-being and ill-being among early-career researchers in the German higher education system.

Differential processes explaining well-being and ill-being of researchers

In research on occupational well-being, job satisfaction—defined as the joy or contentment derived from one's work/occupation—is the most common indicator of well-being (see Rothausen & Henderson, 2019). In contrast, studies of job demands typically use work strain, often operationalized as emotional exhaustion, as the primary indicator of work-related ill-being, both in general employment contexts (see Vander Elst et al., 2012) and within higher education (Naidoo-Chetty & Du Plessis, 2021). A central assumption of job-demands-resources models is that distinct processes give rise to job satisfaction and work strain. This is echoed in higher education research, which treats these variables as separate dimensions characterizing researchers' occupational experience rather than as opposites (see Shin & Jung, 2014). In line with this, the notion that job satisfaction and work strain stem from different mechanisms has gained traction in studies of academic working conditions. Empirical evidence shows, for example, that teaching load and research demands function as job demands linked to emotional exhaustion, whereas support from colleagues and administrative structures can serve as job resources that foster work engagement (see Han et al., 2020; Mudrak et al., 2018).

However, existing studies also highlight that dual process models rely on widely varying measures of job demands and resources in academic contexts. This reflects the broader lack of consensus regarding which factors should be classified as resources or demands. The only point of agreement appears to be that resources are presumed to have positive effects, while demands or stressors exert negative effects. This conceptual vagueness is mirrored in empirical research, where indicators for resources and demands differ considerably across studies. For example, a systematic review of six studies applying the job-demands-resources framework to well-being of academic staff documented substantial variation in how demands and resources were defined (Naidoo Chetty & Du Plessis, 2021).

This conceptual flexibility undermines the generalizability and comparability of findings (Schaufeli & Taris, 2014).

Thus, although dual process models remain appealing for understanding well-being of academic staff, the lack of a clear rationale for identifying resources and stressors hampers efforts to establish a coherent theoretical framework. Nevertheless, existing research offers guidance for refining such a framework. For instance, Naidoo-Chetty and Du Plessis (2021) identified social support, job autonomy, and performance feedback as some of the most consistent resources across studies. Those are factors that align closely with self-determination theory, which provides a well-established framework for understanding the drivers of human well-being and ill-being.

Need satisfaction and frustration as unifying principles for dual processes

Self-determination theory is an organismic meta-theory of human behavior and personality development (Ryan & Deci, 2017). A central tenet of the theory is that optimal well-being depends on individuals' perceptions of their ability to act in alignment with three basic psychological needs: autonomy (the freedom to direct one's own actions), competence (the ability to master challenges), and relatedness (the experience of meaningful social connections). In short, the fulfillment of these needs fosters positive emotions and an overall sense of well-being.

Self-determination theory offers a strong conceptual framework for understanding workplace well-being (for an overview, see Manganelli et al., 2018), as basic psychological needs are directly impacted by factors such as the degree of freedom to carry out one's tasks (autonomy), experiences of mastery (competence) and social climate at work (relatedness). In this sense, a growing body of literature underscores the role of basic psychological needs in shaping occupational experiences, motivation, and behavior among academic staff (Daumiller et al., 2020). For early-career researchers, empirical studies show that need satisfaction supports the pursuit of vocational mastery goals (Janke & Dickhäuser, 2018), intrinsic work motivation, and perceived research success (Stupnisky et al., 2017). Moreover, cross-cultural research indicates that need satisfaction serves as a central psychological predictor of positive affect and vocational learning among academic staff across diverse higher education systems (see Daumiller et al., 2022, for a comparison of German, Indian, and US-American researchers).

Similar to other dual process models, self-determination theory distinguishes need satisfaction and need frustration (i.e., thwarting of and threats to basic psychological needs; Vansteenkiste & Ryan, 2013). Need frustration is not merely the absence of satisfaction but involves active obstruction, pressure, or threat to psychological needs, making it a qualitatively distinct construct. This becomes evident when considering workplace examples among academic staff: For instance, doubts about one's ability to adapt to new teaching technologies reflect uncertainty about whether the need for competence can be satisfied. In contrast, being actively denied opportunities for professional development by supervisors directly frustrates the need for competence. Similarly, feeling disconnected at work (diminished satisfaction of relatedness) differs from experiencing aggressive bullying (frustration of relatedness), the latter involving personal threat rather than a mere lack of opportunity for connection. In line with other dual process models, theorists argue that need satisfaction is more strongly associated with well-being, whereas need frustration supposedly acts as a stronger predictor of ill-being (Vansteenkiste & Ryan, 2013).

An important strength of basic psychological needs theory, compared to other dual process models, is that it offers clear, theory-driven assumptions about what constitutes resources (need satisfaction) and what constitutes stressors (need frustration). Evidence outside of higher education supports this distinction. For example, a pioneering study of US-American secondary school teachers found that need satisfaction was more strongly linked to job satisfaction, while need frustration more strongly predicted intentions to leave the profession (Shim et al., 2022). Additional research indicates that need frustration is closely associated with work strain measured as emotional exhaustion (Olafsen & Marescaux, 2025; Vander Elst et al., 2012). These findings suggest that self-determination theory can meaningfully complement job-demands-resources models. This integration has also been empirically supported in diverse occupational groups, such as nurses (Trépanier et al., 2015) and school principals (Toyama et al., 2022).

In the higher education context, Sabagh and colleagues (2022) demonstrated that frustration of the needs for autonomy, competence, and relatedness mediates the relationship between job demands and work strain. This finding extends earlier work by Naidoo-Chetty and Du Plessis (2021), who identified indicators of need satisfaction as central job resources. Despite growing research on basic psychological needs in academia, to our knowledge, no study has simultaneously examined need satisfaction and need frustration as predictors of job satisfaction and work strain. Additionally, beyond assessing the general relevance of need satisfaction and frustration, we also aim to explore whether individual needs exert unique predictive effects beyond their combined influence. While self-determination theory holds that satisfaction of one need cannot compensate for frustration of another, and that well-being depends on the fulfilment of all three needs (Vansteenkiste & Ryan, 2013), certain contextual factors may elevate the relative importance of specific needs. For example, in a higher education system characterized by strong external pressures, the perceived autonomy of academic staff may play an especially salient role.

The German higher education system as research context

Public discourse on working conditions in German higher education suggests that early-career researchers are unhappy with some aspects of their work conditions that are perceived/reported to increase their work strain and ill-being such as workload and the legal framework of the academic system (Bahr et al., 2021; see Rihl et al., 2024 for respective survey data). This has been prominently illustrated by protests from untenured researchers following a campaign by the Federal Ministry of Education and Science, which sought to rationalize systemic pressures within academia (Bahr et al., 2021). In Germany, tenured positions are extremely limited, and legal regulations restrict nontenured academics to fixed-term contracts of approximately 12 years (with some exceptions), after which they must either obtain a permanent position or leave academia. This places considerable pressure on doctoral candidates and postdoctoral researchers—categorized under the European Framework for Research Careers (European Commission, 2011), as R1 (first-stage researchers, typically pursuing a doctorate) and R2 (recognized researchers, typically postdoctoral, but not yet fully independent). For ease of reference, we use the terms R1 researchers and doctoral candidates interchangeably, as well as the terms R2 researchers and postdoctoral scholars.

Currently, about 96 percent of early-career researchers in R1 and R2 positions in German higher education hold nontenured contracts with an average duration of two to three years

(mean contract duration for postdoctoral researchers = 34 months; Konsortium Bundesbericht Wissenschaftlerinnen & Wissenschaftler in einer frühen Karrierephase, 2025). Although some institutions are experimenting with tenure-track pathways, most R1 and R2 researchers remain in positions without a secure long-term perspective (Schwabe et al., 2024). Career advancement typically depends on the completion of key qualifications: a doctorate for R1 researchers and a habilitation ("second book") for R2 researchers.

The habilitation process, in particular, extends the period of fixed-term employment and deepens dependencies on supervisors, who often also serve as employers and control contract renewals (Schwabe et al., 2024). When it comes to R1 researchers, doctoral education in Germany varies in structure. While some programs follow a traditional "master–apprentice" model with one primary supervisor, others take place within structured graduate programs. However, the system remains largely hybrid: even within graduate schools, doctoral candidates are frequently employed by senior researchers (typically tenured professors) who act as primary supervisors (Meuleners et al., 2023). It is worth noting that in Germany, doctoral candidates are often employed as academic staff with teaching and administrative responsibilities, similar to postdoctoral researchers. In sum, the prevalence of fixed-term contracts, intense competition, and complex dependencies on individual supervisors represent systemic pressure points for R1 and R2 researchers in Germany (Bahr et al., 2021).

Regardless of these pressures, past survey data indicates that 73 percent of early-career researchers would prefer to remain in academia if more reliable pathways to permanent positions were available (Briedis et al., 2014). This supports the view that German early-career researchers experience their work to be desirable despite their growing discontent with parts of their working conditions (Rihl et al., 2024). This coexistence exemplifies the notion that occupational well-being and ill-being can coexist. Working conditions characterized by high strain due to employment uncertainty (see Davidson et al., 2023; Rihl et al., 2024), alongside enough pull factors to enforce the wish to remain in academia make the German higher education system a highly suitable context for investigating how psychological mechanisms related to need satisfaction and need frustration contribute to patterns of well-being and ill-being in academic work.

The nuanced well-being patterns among German early-career researchers also call for a complex view on the construct, specifically by unpacking the concept of job satisfaction. As aforementioned, untenured academic staff in Germany frequently report dissatisfaction with their prospects for attaining a tenured position. However, this does not necessarily imply dissatisfaction with other aspects of their work. This raises the question of whether need frustration is particularly predictive of dissatisfaction with career advancement opportunities. To explore this, we adopt the framework proposed by Kinicki and colleagues (2002), which conceptualizes job satisfaction as comprising multiple dimensions: satisfaction with coworkers, pay, personal development, work tasks, and supervision. This approach moves beyond the traditional, often one-dimensional measures of job satisfaction still commonly used in studies investigating academic staff (e.g., Lacy & Sheehan, 1997; Mudrak et al., 2018) and aligns well with the complex reality of German early career researchers. In this regard, we expect that untenured doctoral candidates (R1) and postdoctoral researchers (R2) in the German higher education system will show lower satisfaction with opportunities for personal development. Notably, the dimensions of the theoretical framework by Kinicki and colleagues (2002) connect very well to other (often rather eclectic) multi-dimensional frameworks of job satisfaction within higher education research (see, for instance, Rihl et al., 2024, for a comparable approach).

Research questions

This study has three main objectives. First, we aim to deepen understanding of the nuanced patterns of job satisfaction and work strain among first-stage researchers pursuing doctorates (R1) and recognized postdoctoral researchers (R2) in the German higher education system. Specifically, we explore the multifaceted nature of job satisfaction, expecting to find both areas of satisfaction and areas of dissatisfaction, particularly concerning opportunities for personal development. Regarding the effect of career stage, we hypothesize that particularly doctoral candidates report less strain regarding career development opportunities (H1), as they are typically less firmly committed to an academic career than postdoctoral researchers. Second, we investigate the role of basic psychological needs in shaping job satisfaction and work strain. Consistent with dual process models, we conceptualize need satisfaction as a central resource and expect it to be more strongly associated with job satisfaction than need frustration (H2). Conversely, we expect need frustration to function as a stressor and to be more strongly associated with work strain, operationalized as emotional exhaustion, than need satisfaction (H3). Third, we explore whether individual psychological needs differ in their respective predictive power for job satisfaction and work strain among untenured academic staff in Germany (exploratory research question).

Method

We surveyed German academic staff members through an online questionnaire distributed at two medium-sized universities in southern Germany. The survey was part of a broader project evaluating working conditions at these institutions for untenured academic staff. Together, the two universities represent a wide range of scientific disciplines, offering approximately 250 study programs to around 42,000 students, supported by 7750 researchers. These universities offer both traditional doctoral pathways (single-supervisor models) and structured graduate schools. The survey was disseminated via staff mailing lists, direct outreach, and snowball sampling. Informed consent was obtained from all participants.

Sample

A total of 425 academic staff members completed the survey. As our focus was on untenured early-career researchers, we excluded participants with permanent employment or tenure ($n=54$), as well as four participants not employed in higher education. The final sample comprised 367 untenured staff members (53.4 percent female, 1.1 percent diverse; $M_{age}=33.15$ years, $SD=6.78$ years). Of these, 60.5 percent were doctoral candidates (R1 career stage), and 39.5 percent were postdoctoral researchers (R2 career stage). The average contract duration was 24.78 months for doctoral candidates (Median = 24 months, Mode = 36 months; $SD=13.32$ months), and 29.67 months for postdoctoral researchers (Median = 31 months, Mode = 36 months; $SD=14.31$ months).

Measures

Need satisfaction/Frustration at work

We assessed satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness using the German version of the Balanced Measure of Psychological Needs (Sheldon & Hilpert, 2012), adapted for the workplace by adding the prefix "At work…" to each item (e.g., autonomy satisfaction: "At work, I am free to do things my own way"). The scale includes six items per need, with half measuring need satisfaction and half measuring need frustration. Responses were recorded on a 7-point Likert scale (1 = "does not apply at all"; 7 = "applies very strongly"). The theoretical rationale behind this scale follows a number of studies that measured basic psychological need satisfaction in academic staff (e.g., Daumiller et al., 2022; Stupnisky et al., 2018). The *internal consistencies* of the subscales in our sample ranged from $\alpha = .68$ to $\alpha = .92$ (see Table 1), indicating sufficient to very good reliability, particularly given the brevity of the scale. Notably, internal consistencies were higher for the need satisfaction subscales ($\alpha = .75$ to .92) than for the need frustration subscales ($\alpha = .68$ to .76). Regarding this measure's validity, prior research has demonstrated strong associations with daily fluctuations in need satisfaction of academic staff (Janke & Dickhäuser, 2018). In addition, the theoretical measurement model showed good fit in the present study (see Results), further supporting the validity of the scale.

Job satisfaction

In line with our multidimensional approach to job satisfaction, we used the German Questionnaire for General and Facet-Specific Job Satisfaction (Haarhaus, 2015), which is closely based on the English Job Descriptive Index (Kinicki et al., 2002). The questionnaire assesses satisfaction across five specific facets: work tasks (e.g., "My work tasks are interesting."), colleagues (e.g., "My colleagues are nice."), personal supervisors (e.g., "My supervisor is trustworthy."), opportunities for personal development (e.g., "My opportunities for personal development are appropriate."), and pay (e.g., "My payment is fair."); each measured with five items. In addition, it includes a general job satisfaction scale (e.g., "Overall, my occupation is satisfying."), also consisting of five items. Some scales included up to three negatively worded items assessing dissatisfaction that were reverse-coded to ensure consistent response scaling before analysis. As with the previous scales, responses were recorded on a seven-point Likert scale (1 = "not at all true"; 7 = "very true"). The internal consistencies of all subscales ranged from $\alpha = .79$ to $\alpha = .94$, indicating satisfactory to excellent reliability (see Table 1). Confirmatory factor analysis further supported the factorial validity of the scale (six independent but correlated subscales), yielding acceptable model fit: $\chi^2(390) = 690.39$, $p < .001$, CFI = .95, TLI = .95, SRMR = .04, RMSEA = .07.

Work strain

We measured emotional exhaustion, as a potential consequence of need frustration, using the emotional exhaustion subscale of the Maslach Burnout Inventory (German version: Büssing & Perrar, 1992). The subscale consists of seven items (e.g., "My work frustrates

Table 1 Descriptive statistics and zero-order correlations

Scale	M	SD	α	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Autonomy satisfaction	5.39	1.07	.75												
(2) Autonomy frustration	3.21	1.26	.68	-.54**											
(3) Competence satisfaction	5.74	1.05	.92	.37**	-.20**										
(4) Competence frustration	2.82	1.28	.76	-.12*	.35**	-.47**									
(5) Relatedness satisfaction	5.31	1.43	.92	.17**	-.12*	.10	-.09								
(6) Relatedness frustration	2.37	1.33	.71	-.25**	.38**	-.12*	.23**	-.49**							
(7) Work strain	3.21	1.51	.92	-.31**	.57**	-.28**	.44**	-.20**	.44**						
(8) General job satisfaction	5.65	1.14	.88	.45**	-.45**	.28**	-.22**	.33**	-.42**	-.51**					
(9) Satisfaction with work tasks	5.70	0.98	.79	.52**	-.33**	.27**	-.09	.24**	-.29**	-.32**	.51**				
(10) Satisfaction with colleagues	5.71	1.19	.90	.28**	-.37**	.08	-.08	.47**	-.64**	-.39**	.53**	.31**			
(11) Satisfaction with supervisors	5.48	1.47	.92	.32**	-.47**	.13*	-.14**	.20**	-.37**	-.42**	.48**	.24**	.45**		
(12) Satisfaction with pay	4.86	1.73	.94	.18**	-.16**	.08	-.07	.10	-.16**	-.18**	.33**	.17**	.24**	.16**	
(13) Satisfaction with opportunities for personal development	4.08	1.73	.92	.30**	-.29**	.09	.01	.18**	-.26**	-.27**	.45**	.29**	.38**	.36**	.18**

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

All scales ranged from 1 to 7

me."), assessed using the same seven-point Likert scale employed for measuring need satisfaction and frustration (1 = "does not apply at all"; 7 = "applies very strongly"). The scale demonstrated excellent internal consistency in our sample (α = .92).

Analytic strategy

For our main analyses, we conducted structural equation modeling to examine associations between all predictor and criterion variables simultaneously, using Mplus version 8.6. Model estimation was performed with the Weighted Least Square Means and Variance Adjusted (WLSMV) estimator, which is well suited for handling multivariate non-normality and items with noncontinuous response distributions. This was particularly relevant, as several items measuring need satisfaction and frustration exhibited strong non-normality, with sometimes more than 80 percent of responses clustering within two categories. Additionally, WLSMV performs well with smaller sample sizes, which was advantageous given the moderate size of our sample (Moshagen & Musch, 2014).

Our measurement model followed the approach proposed by Sheldon and Hilpert (2012), who provided empirical support for a bi-factor model as the best representation of the Balanced Measure of Psychological Needs. In this model, all items load simultaneously on two uncorrelated general factors (need satisfaction and need frustration) and on one of three uncorrelated specific factors (autonomy, competence, and relatedness). The general factors capture shared variance across needs, while the specific factors reflect variance uniquely attributable to each individual need.

The bi-factor model allows us to dive deeper into the unique importance of the three needs above their shared contributions to explaining job satisfaction and work strain. A limitation of this bi-factor approach is that the valence of need experiences (whether they reflect satisfaction or frustration) is modeled only at the general factor level. The specific factors (autonomy, competence, relatedness) capture need content but not valence. As a result, differential effects of satisfaction versus frustration cannot be interpreted at the level of individual needs but only for the general need satisfaction and frustration dimensions (reflecting shared valence across all needs). Yet, the findings by Sheldon and Hilpert (2012) strongly suggest that the alternative—meaning a model that distinguishes satisfaction and frustration on the level of single needs without taking shared variance into account—does not accurately reflect the reality of need satisfaction/frustration. However, to provide the most comprehensive picture possible, we still chose to report descriptive data and zero-order correlations for satisfaction/frustration of single needs. This way, it becomes possible to interpret our data both under the lens of the more complex bi-factor model, in which the unique effects of needs represent residual associations against the backdrop of controlling for shared variance, as well as a more simplified approach that allows to infer more about composite effects of need satisfaction/frustration and need content.

In the final structural model, we regressed all facets of job satisfaction and work strain on the latent variables derived from the bi-factor model. We allowed for associations between the criteria. As the latent bi-factor modelling corresponds with a need for a high number of estimated parameters, we chose to include all subscales of job satisfaction as well as the scale measuring work strain as manifest scores (scale means) to keep model complexity moderate. When testing for the relative importance of need satisfaction in comparison to need frustration at work as predictors of job satisfaction and work strain, we examined whether the 95% CIs around the standardized path coefficients overlapped in magnitude (regardless of their direction/sign). If this was not the case, we interpreted

the predictive power as different between the two variables. The Mplus data file as well as the input and output files of the conducted models are openly accessible at https://osf.io/x6pmr/.

Results

We initially examined descriptive statistics, specifically, the mean values and zero-order correlations of all study variables. All relevant statistics are depicted in Table 1.

Descriptive analyses revealed that nontenured academic staff generally reported relatively high levels of job satisfaction, with mean values for most facets exceeding five on the seven-point scale. Notable exceptions emerged for satisfaction with pay and satisfaction with opportunities for personal development. In particular, satisfaction with personal development showed the lowest mean and the highest standard deviation, suggesting elevated variability in how staff members experience this aspect of their work. In terms of work strain, respondents reported moderate levels of emotional exhaustion, with mean values slightly below the midpoint of the scale and considerable variability. Regarding basic psychological needs, the data show generally high levels of need satisfaction and lower levels of need frustration. However, the gap between satisfaction and frustration was smallest for autonomy, suggesting that staff members simultaneously experience both a sense of autonomy and external pressures in their work environments. As expected, the zero-order correlations show that need satisfaction was positively associated with all facets of job satisfaction and negatively associated with work strain, whereas need frustration showed the opposite pattern.

To further explore group differences, we conducted a multivariate analysis of variance (MANOVA) comparing mean values across career stages (R1 vs. R2). The MANOVA revealed a significant multivariate effect, *Hotelling's* $T = 0.11$, $F(13, 353) = 2.90$, $p < .001$, $\eta^2 = .10$. The multivariate group differences were expressed through five significant univariate effects (see also Table 2): Postdoctoral researchers (R2) reported significantly lower satisfaction with opportunities for personal development but higher satisfaction with pay, consistent with typical salary progression between doctoral and postdoctoral phases. Additionally, postdoctoral researchers were somewhat less satisfied with their colleagues compared to doctoral candidates (R1). For basic psychological needs, postdoctoral researchers reported higher frustration of autonomy but greater satisfaction of competence compared to doctoral candidates.

Structural equation model

As a first step in examining the associations between need satisfaction and frustration at work and the outcome variables, we tested whether the postulated bi-factor measurement model of need satisfaction vs. frustration fitted the data well. This was generally the case; $\chi^2(118) = 419.68$, $p < .001$, CFI = .98, TLI = .97, SRMR = .07. Only the RMSEA value of .083 slightly exceeded the conventional cutoff of RMSEA $\leq .08$; however, given the overall pattern of fit indices and the small magnitude of this deviation, we still consider the model fit to be acceptable. This also means that the data supports the factorial validity of the scale (along with factor loadings and substantial amount of variance attributable to all latent factors), indicating that the items capture both general variance related to need satisfaction

Table 2 Group differences between doctoral candidates and post-docs

	DC		Post-Docs		Comparison		
	M	*SD*	*M*	*SD*	*F*(1,365)	*p*	η^2
Autonomy satisfaction	5.36	1.12	5.42	0.98	0.40	.527	.00
Autonomy frustration	**3.10**	**1.31**	**3.38**	**1.17**	**4.33**	**.038**	**.01**
Competence satisfaction	**5.64**	**1.08**	**5.88**	**1.00**	**4.23**	**.040**	**.01**
Competence frustration	2.87	1.29	2.76	1.27	0.71	.401	.00
Relatedness satisfaction	5.38	1.46	5.21	1.40	1.19	.277	.00
Relatedness frustration	2.31	1.29	2.48	1.39	1.40	.237	.00
Work strain	3.14	1.51	3.32	1.52	1.20	.275	.00
General job satisfaction	5.71	1.11	5.56	1.20	1.41	.236	.00
Satisfaction with work tasks	5.64	0.96	5.79	1.01	2.09	.149	.01
Satisfaction with colleagues	**5.84**	**1.17**	**5.54**	**1.19**	**5.70**	**.018**	**.02**
Satisfaction with supervisors	5.59	1.45	5.31	1.49	3.12	.078	.01
Satisfaction with pay	**4.69**	**1.81**	**5.11**	**1.56**	**5.41**	**.021**	**.02**
Satisfaction with opportunities for personal development	**4.28**	**1.74**	**3.77**	**1.66**	**7.73**	**.006**	**.02**

DC doctoral candidates; Boldness indicates statistically significant group differences

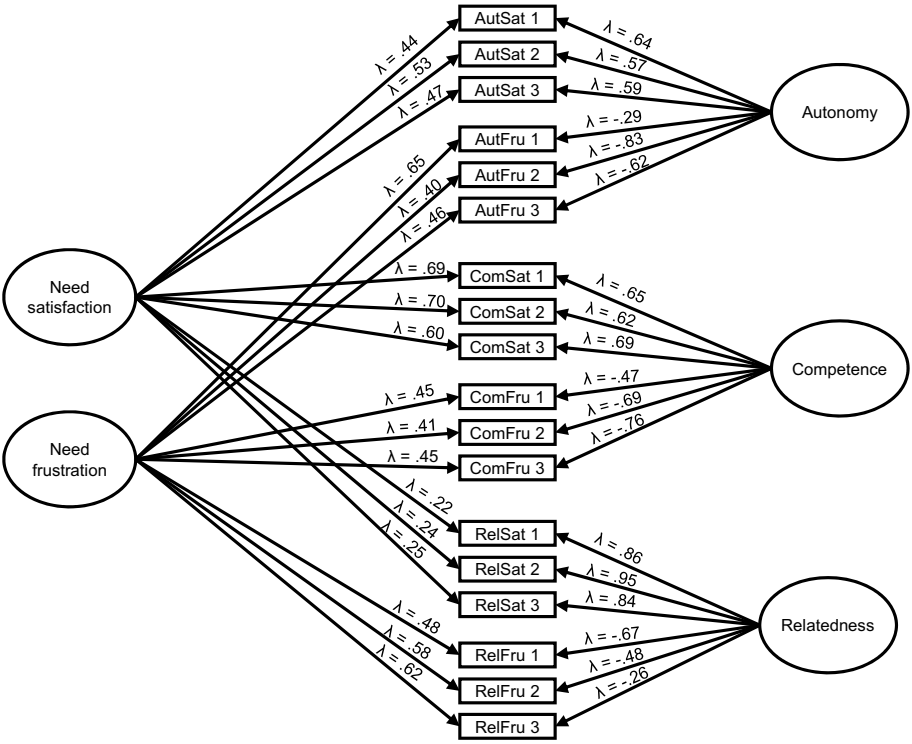

Fig. 1 Visualization of the bi-factor measurement model for basic psychological needs. All path coefficients are significant with $p<.001$

and frustration, as well as unique variance associated with the three individual needs (autonomy, competence, relatedness). The full measurement model is presented in Fig. 1.

In the second step, we estimated the hypothesized structural model, which also demonstrated acceptable fit; $\chi^2(209) = 621.96$, $p < .001$, CFI = .96, TLI = .95, SRMR = .06, RMSEA = .07. The full model and all path coefficients are presented in Table 3. The overall pattern of results indicates that both need satisfaction and need frustration at work were significantly associated with job satisfaction and work strain. Specifically, need satisfaction positively predicted all facets of job satisfaction and negatively predicted work strain, whereas need frustration showed the opposite pattern—negative predictive power for job satisfaction and positive predictive power for work strain. Importantly, the full set of predictors explained substantial proportions of variance for all criteria ($R^2 > .35$) except satisfaction with pay ($R^2 = .07$, $p = .060$).

When it comes to the relative importance of need frustration versus need satisfaction at work, comparisons of the confidence intervals of the path coefficients only pointed to two meaningful differences: need satisfaction (β = .49, 95% CI [.39, .59]) was a stronger predictor for satisfaction with work tasks than need frustration (β = −.24, 95% CI [−.34, −.12]); conversely, need frustration (β = .67, 95% CI [.59, .74]) was a stronger predictor for work strain than need satisfaction (β = −.32, 95% CI [−.42, −.22]).

Regarding variance attributable to individual needs, distinct patterns emerged as well. Experiences of autonomy positively predicted satisfaction with work tasks, supervision, and overall job satisfaction, while also negatively predicting work strain. Relatedness showed similar effects by positively predicting satisfaction with work tasks, and overall job satisfaction, as well as negatively predicting work strain. Adding to this, relatedness also positively predicted satisfaction with colleagues. Unexpectedly, a sense of competence negatively predicted satisfaction with colleagues, supervision, and personal development opportunities. Importantly, these findings must be interpreted against the backdrop that associations between the unique variance bound to each need and the outcome variables are highly controlled for the effects of general need satisfaction/frustration as well as the other two needs.

Discussion

Our study aimed to clarify how need satisfaction and frustration function as psychological resources or stressors for untenured academic staff in (German) higher education. Descriptive results suggest that early-career researchers experience relatively high job satisfaction alongside moderate strain, which supports the view that satisfaction and strain are distinct dimensions for higher education academic staff, as posited in job-demands-resources models (e.g., Han et al., 2020; Mudrak et al., 2018). Regarding basic psychological needs, both need satisfaction and frustration predicted job satisfaction and work strain, consistent with a dual process model of well-being and ill-being. The expected distinct patterns reflecting such a process model within academic staff were most accentuated for work strain, where need frustration proved to be a considerably more powerful predictor than need satisfaction. In addition to the overall effects of need satisfaction and frustration, we find that unique variance linked to the individual needs of autonomy and relatedness contributed meaningfully to the outcomes. Findings for competence were more complex, showing some unexpected negative associations when controlling for shared variance with the other needs.

Table 3 Path coefficients from the structural equation model

	Work strain	General job satisfaction	Satisfaction with work tasks	Satisfaction with colleagues	Satisfaction with supervisors	Satisfaction with pay	Satisfaction with opportunities for personal development
Need satisfaction	**β = −.32** **95% CI [−.42, −.22]** ***p* < .001**	**β = .43** **95% CI [.33, .53]** ***p* < .001**	**β = .49** **95% CI [.39, .59]** ***p* < .001**	**β = .41** **95% CI [.29, .53]** ***p* < .001**	**β = .36** **95% CI [.25, .47]** ***p* < .001**	**β = .17** **95% CI [.05, .28]** ***p* = .019**	**β = .41** **95% CI [.28, .53]** ***p* < .001**
Need frustration	**β = .67** **95% CI [.59, .74]** ***p* < .001**	**β = −.42** **95% CI [−.51, −.33]** ***p* < .001**	**β = −.24** **95% CI [−.34, −.13]** ***p* < .001**	**β = −.55** **95% CI [−.63, −.48]** ***p* < .001**	**β = −.50** **95% CI [−.60, −.40]** ***p* < .001**	**β = −.16** **95% CI [−.27, −.06]** ***p* = .011**	**β = −.34** **95% CI [−.44, −.23]** ***p* < .001**
Autonomy (unique variance)	**β = −.15** **95% CI [−.23, −.08]** ***p* = .001**	**β = .23** **95% CI [.16, .30]** ***p* < .001**	**β = .30** **95% CI [.21, .38]** ***p* < .001**	β = .04 95% CI [−.04, .12] *p* = .395	**β = .16** **95% CI [.07, .24]** ***p* = .004**	β = .10 95% CI [.01, .19] *p* = .059	β = .07 95% CI [−.02, .17] *p* = .212
Competence (unique variance)	β = −.09 95% CI [−.19, .04] *p* = .116	β = −.03 95% CI [−.13, .07] *p* = .631	β = −.06 95% CI [−.17, .04] *p* = .328	**β = −.28** **95% CI [−.39, −.18]** ***p* < .001**	**β = −.18** **95% CI [−.29, −.07]** ***p* = .006**	β = −.03 95% CI [−.13, .08] *p* = .683	**β = −.28** **95% CI [−.40, −.17]** ***p* < .001**
Relatedness (unique variance)	**β = −.11** **95% CI [−.20, −.02]** ***p* = .039**	**β = .25** **95% CI [.16, .34]** ***p* < .001**	**β = .14** **95% CI [.06, .23]** ***p* = .004**	**β = .40** **95% CI [.32, .48]** ***p* < .001**	β = .11 95% CI [.01, .20] *p* = .056	β = .08 95% CI [−.01, .17] *p* = .120	β = .07 95% CI [−.02, .17] *p* = .194
	R^2 = .59, *p* < .001	**R^2 = .48, *p* < .001**	**R^2 = .41, *p* < .001**	**R^2 = .71, *p* < .001**	**R^2 = .45, *p* < .001**	R^2 = .07, *p* = .060	**R^2 = .37, *p* = .002**

Boldness indicates statistical significances

Theoretical implications

Our findings support the value of a dual process model grounded in self-determination theory for explaining patterns of well-being and ill-being in academic staff. In contrast to prior research into job-demands-resources models, which often defines resources and stressors post hoc, our approach allows these constructs to be specified a priori, helping to unify an otherwise fragmented literature (Naidoo-Chetty & Du Plessis, 2021). Specifically, we propose that satisfaction of basic psychological needs (autonomy, competence, relatedness) serves as a key resource, while their frustration functions as a critical stressor.

We found that the premises of the investigated dual process model were holding most consistently for work strain in terms of emotional exhaustion as this aspect of ill-being was more sensitive to need frustration than to need satisfaction. For overall job satisfaction, the pattern was less distinct. However, looking more closely at facets of well-being, particularly satisfaction with work tasks was indeed more strongly bound to need satisfaction at work than to need frustration. A plausible explanation is that satisfaction with work tasks reflects task-based autonomous motivation, meaning engaging in a task out of one's own volition for the sake of the task itself (Koestner et al., 2008). This aligns well with prior job-demands-resources studies that emphasize task engagement as a core indicator of workplace well-being that strongly depends on psychological resources (Han et al., 2020).

Other aspects of job satisfaction are notably more externally driven than task engagement: Satisfaction with colleagues and supervisors reflects interpersonal dynamics, while opportunities for personal development often depend on systemic factors. As such, it seems fitting that need frustration, which is often the result of external influences and pressures, plays a stronger role in predicting these aspects than in shaping satisfaction with work tasks. Notably, neither need satisfaction nor frustration was meaningfully associated with satisfaction with pay, which highlights that assumptions on linear associations between basic psychological needs and salary might be an oversimplification of a more complex reality.

Our findings also reinforce the distinct roles of all three basic needs as resources and stressors, each showing unique associations with the outcomes. Rather unsurprisingly relatedness was strongly linked to satisfaction with colleagues. Adding to this, we find distinct associations between feelings of autonomy at work and satisfaction with personal supervisors. In this regard, causal interpretations are limited by the cross-sectional nature of our data. While we conceptualized needs as resources supporting well-being, it is equally plausible that supportive colleagues foster relatedness, and that autonomy is enabled by supervisors who grant academic freedom.

More puzzling were the negative associations between feelings of competence and certain aspects of job satisfaction. These results suggest that, for nontenured R1 and R2 researchers, competence may be a less consistent psychological resource than autonomy or relatedness. This stands in notable contrast to research in other work contexts where competence satisfaction emerges as a consistent resource for employees' well-being (Nunes et al., 2024). An explanation could lie in the structure of the German system, where a narrow pathway to tenured positions may frustrate those who feel competent but remain on limited contracts. This aligns with our finding that negative associations for competence were strongest in relation to external/interpersonal aspects of the scientific system such as supervisors, colleagues, and opportunities for personal

development. Importantly, additional analyses controlling for career phase (which was positively linked to sense of competence) did not reflect group differences regarding the strength of the associations (see OSF file), suggesting that even doctoral candidates with high competence experience dissatisfaction with career prospects and their work environment.

Practical implications

A central takeaway from our study is that nontenured R1 and R2 researchers in our sample generally "liked" their jobs. On average, they reported high satisfaction with their work tasks, colleagues, and supervisors, and experienced a strong sense of autonomy in the workplace. However, this was accompanied by moderate work strain and only moderate satisfaction with opportunities for personal development, with postdoctoral researchers reporting even lower satisfaction with their career prospects than doctoral candidates. These patterns strongly connect to the ongoing debate around limited career opportunities in German higher education. In this regard, it is interesting to note that the rather high level of need satisfaction in the sample seems not to have been sufficient to provide a foundation for lowering experienced work strain and dissolving dissatisfaction with lacking opportunities. This could speak to the core issue that need supportive work structures cannot fully counteract a pressuring scientific system. Rather, it seems paramount that systemic measures are enacted to lift the burden that nontenured early career researchers in Germany are facing (as discussed by Bahr et al., 2021).

Nevertheless, our findings still reinforce the importance of fostering a need-supportive work environment in higher education. Autonomy and relatedness, in particular, appear central to job satisfaction, which mirrors prior investigations that illustrated positive associations of satisfaction of these particular needs with researchers day-to-day learning goal striving and work engagement (Janke & Dickhäuser, 2018). A supportive work culture that also allows for academic freedom thus seems key to promoting both well-being and a focus on learning. Conversely, a pressuring, competitive environment characterized by social ostracism may heighten strain. It is important to note that extreme cases of experienced work strain can result in burnout, which drastically impairs the performance of academic staff members (Sabagh et al., 2018). Higher education administrators should consider these risks when shaping institutional culture.

Limitations and future research

The present study is based on cross-sectional data and does not permit strong causal inferences. While prior self-determination theory research has established a sturdy foundation for the idea that need satisfaction facilitates the development of well-being or ill-being, respectively (e.g., Cordeiro et al., 2016), we remain cautious in interpreting associations with specific job satisfaction facets. Some facets, such as satisfaction with colleagues, may themselves act as need-supportive factors (particularly for relatedness) echoing research that highlights social support through colleagues as a key resource in academic settings (Naidoo-Chetty & Du Plessis, 2021). Clarifying these dynamics will require further longitudinal evidence.

Future longitudinal studies should also examine the ultimate consequences of well-being and ill-being in academia. While we demonstrate that need satisfaction and frustration relate to current well-being, it is likely they also influence career persistence. Academic

staff experiencing chronic ill-being may be more likely to leave the profession (Dorenkamp & Weiß, 2018). Given that feelings of competence did not emerge as a strong buffer in our sample, even highly talented researchers may be at risk of attrition, representing a potential loss of high potentials to the academic system.

Adding to this, our study did not examine factors that may underlie variation in need satisfaction and frustration among academic staff. Future research should explore such contextual antecedents, such as intellectual freedom, grant pressures, or the balance between teaching and research. Insights into these influences would be valuable for higher education practitioners seeking to promote need satisfaction and mitigate need frustration.

Regarding the present study's specificity, two limitations warrant mention. First, our findings are situated within the German higher education system, where limited career prospects may contribute to the maladaptive patterns observed for sense of competence. Cross-cultural research is needed to assess the universality versus context-specificity of this and other associations uncovered in this study. Second, our sample does not claim to be representative for academic staff in Germany as we only sampled in two universities that have not been picked for reasons of typicality. Adding to this, our sample does not allow for deeper investigations into scientific disciplines or varieties of doctoral training. While we expect the identified psychological mechanisms to generalize between scientific areas, future work might want to explore the role of disciplinary and institutional context more systematically.

Conclusion

This study adds to the evidence that basic psychological needs are central to dual process models of early-career researchers' well-being. The strong link between need satisfaction and job satisfaction highlights potential strategic measures institutions and supervisors could pursue to support academic staff. These findings are especially relevant for untenured R1 and R2 researchers, who may be particularly vulnerable to the negative effects of need frustration. However, while fostering need satisfaction can improve working conditions, such efforts cannot fully offset systemic issues, such as competitive pressures that undermine autonomy or limited career opportunities that can counteract general experiences of accomplishment.

Authors' contributions Stefan Janke: Conceptualization; resources; data curation; methodology; formal analysis; supervision; writing—original draft. Ronja Steinhauser: Conceptualization, writing—review and editing. Henrike Helmer: Conceptualization, investigation, resources, project administration, writing—review and editing. Martin Daumiller: writing—review and editing. Oliver Dickhäuser: writing—review and editing.

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Data availability Data on all relevant variables as well as all syntax files that were used to analyze the data set are openly accessible through the OSF (Link: https://osf.io/x6pmr/)

Declarations

Ethics approval and consent to participate The presented research fully complies with ethical standards raised by the German Association of Psychologists (DGPs) and the American Psychological Association

(APA). All participants were informed about the purpose of the research conducted, that they could quit the questionnaire at any time and that all their responses would remain confidential.

Competing interests The authors declare that they have no competing interests.

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