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Basic needs support and achievement emotions in daily research of life scientists considering academic positions

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Emotions are a crucial factor in daily research of academic staff and, accordingly, affect scientific progress. Already before but especially during the COVID-19 pandemic, the strong connection between working conditions and work-related emotional states as antecedents for mental health of academic staff gained more and more attention. However, in depths investigations of researchers' emotions in academia are still rare. In the highly competitive field of academia, experiencing the working environments as supportive may be an important influential factor for researchers' emotions. On a structural level, academic positions may also be tied to different emotional experiences. Taking a Self-Determination Theory approach, we therefore investigate, whether a basic need-supportive environment (regarding perceived competence and autonomy support, and social relatedness to the scientific community) and the academic position (research assistants without leading responsibility and principle investigators with leading responsibility) predict activity-related achievement emotions (enjoyment, anger, frustration, and boredom) during daily research activities. However, measurements on basic needs support and achievement emotions tailored to the specific academic research context are lacking. Therefore, this study is aimed at developing fitted scales on these constructs. In a cross-sectional survey, we questioned N = 250 life scientists in 13 German universities. Results of multiple linear regression analyses suggest that supportive environments in academia were positively associated to the level of experienced enjoyment and negatively to the level of experienced frustration. Surprisingly, social relatedness to the scientific community does not affect frustration. Principle investigators report a more favorable emotional pattern with higher levels of enjoyment than research assistants. However, the level of experienced frustration was not affected by the academic position. The scales on anger and boredom seemed not to differentiate emotional experiences on these two negative achievement emotions in the research context accurately. Therefore, we needed to exclude

anger and boredom from analyzes. Further research on these achievement emotions is needed. We discuss our findings on enjoyment and frustration and derive both theoretical and practical implications, taking an international and interdisciplinary perspective.

Introduction

The COVID-19 pandemic had shown how closely scientific research is sometimes linked to emotional experiences. All of a sudden, the whole world had started to follow scientific progress in an unprecedented way. People were waiting for vaccines or drugs against COVID-19, hoping that these tools will help life get back to normal and COVID-19 will no longer disrupt everyday work and personal lives to such a great extent (Restubog et al., 2020). No wonder that communication between researchers and society regarding the COVID-19 pandemic was getting emotional (Chou and Budenz, 2020). However, the link between emotions and research is not a new discovery, although it was not often that obvious on a large scale as was the case during the COVID-19 pandemic. Previous research argues that scientific discoveries are impossible without emotions (Fischer et al., 2014). Tran et al. (2021) showed in their study that academic staff often reached their workload limits due to continuously changing requirements for academic work including research and teaching during the COVID-19 pandemic. Resulting from the circumstances during the pandemic, faculty begun to increasingly evaluate the emotional state of their academic staff (Tran et al., 2021). Evaluating the emotional state of academic staff showed that, e.g., anxiety is common. The emotional state is closely linked to emotional, mental, and physical exhaustion indicating burnout (Tran et al., 2021). Tran et al. (2021) concluded that evaluating the emotional state is relevant for estimating general well-being of academic staff and for preventing burnout (Tran et al., 2021). Furthermore, there is empirical evidence that emotions are important drivers for many psychological aspects related to scientific success, such as motivation (e.g., Løvoll et al., 2017), well-being (e.g., Pekrun, 2006), and academic achievement (e.g., Pekrun et al., 2017; Forsblom et al., 2021).

However, despite the relevance of emotions during research investigations on emotions of academic staff are rare. Most research on emotions in academic contexts focused on school contexts (e.g., Pekrun, 2006) and undergraduate programs in the higher education context (e.g., Pekrun and Stephens, 2010; Umucu et al., 2022). To close this research gap, we examined in this study how academia can promote positive emotional

experiences of researchers during research. Specifically, we investigate perceptions of supportive conditions within the academic environment for positive emotional experiences during daily research considering the academic position.

Doing research in academia

In a first step, we give a brief overview about structural conditions for researchers in academia. We describe research conditions from an international perspective and add some specific information on the German academic system, in which our study is situated.

Academic activities include doing research, teaching, service (including service to clients, consulting, and public service), administration, and other related activities (Teichler et al., 2013). However, researchers' core task is doing research (Boyer, 1990). Competition and pressure to perform determine research in universities. In most academic systems, only those who successfully publish their research and raise external funds for new research projects get a chance for the next academic position and, finally, a permanent position (Kwiek and Antonowicz, 2015). Some academic systems come with further structures that put pressure on junior researchers. In Germany, for example, the length of fixed-term employment for scientific qualifications (such as the doctorate and habilitation) before a permanent position must be obtained, is set at 12 years in total (plus possible extension for specific reasons, such as childcare) (Law on fixed-term employment contracts in academia [WissZeitVG], 2016, §2, Abs. 1). There is an imbalance between only few professorship positions to be filled and many trained junior researchers, who are forced to get a permanent position before the 12 years fixed time for qualification expires in order to continue working in the academic system (Krempkow et al., 2014; Consortium for the National Report on Junior Scholars [BuWiN], 2021).

Simultaneously, there are some shortfalls in structural working conditions in academia, which can hamper long-term academic careers: Previous studies showed that academia lacks structures for career advancement (Krempkow, 2010), lacks professorship positions and alternative permanent positions

(Consortium for the National Report on Junior Scholars [BuWiN], 2021), and scientific careers are often difficult to match with family planning (Krempkow and Sembritzki, 2017). Furthermore, researchers are employed mostly with fixed-term and part-time contracts during the doctorate and even as post-doctoral researchers while working hours over time is required (Teichler et al., 2013; Krempkow et al., 2014; Krempkow, 2017; Consortium for the National Report on Junior Scholars [BuWiN], 2021). There are already tendencies to improve structural working conditions at the university (Höhle and Teichler, 2016): there is an increasing amount of personal development offers (Krempkow et al., 2016) and more permanent positions are set up (Krempkow, 2017). However, doing research in academia still comes with highly competitive working conditions in mostly insecure career paths.

Typically, an academic career path is separated into four career stages (European Commission [EC], 2011): (1) during doctoral studies, doctoral candidates as first stage researchers gain their initial scientific experiences. (2) As recognized researchers, doctoral graduates, who are mostly employed as research assistants, gain further scientific experiences in post-doctoral research. (3) In a third step, established researchers take responsibility for guiding other scientists, e.g., in Germany as junior research group leaders, junior professors, and in tenure-track-professorships (Consortium for the National Report on Junior Scholars [BuWiN], 2021). (4) Taking the last career step, researchers do independent scientific research as full professors in permanent employment (European Commission [EC], 2011). The degree of independence regarding research activities differs between the stages of an academic career. Mainly, there is a difference of independency in research between the first two stages (1)–(2) and the last two stages of an academic career (3)–(4). Research assistants (1)–(2) and principle investigators (hereafter referred to as PIs) (3)–(4) differ in their research activities: Research assistants mostly are limited in their independency of scientific research and their mostly fixed-term employment is insecure. In contrast, PIs hold mostly permanent positions (full professors) or have a permanent position in prospect (junior research group leaders, junior professors). They conduct already somewhat independent scientific research. Nevertheless, research assistants usually spend more time on research than PIs, who in contrast teach more than research assistants (Höhle and Teichler, 2016).

In other professional contexts, positions within an organization are relevant for emotions: Previous research has provided evidence that the status within an organization influences expression of emotions (e.g., anger in the workplace) and emotional patterns are associated with positions: persons in leading positions express emotions (e.g., anger, pride) more frequently than subordinated persons (Tiedens et al., 2000; Sloan, 2004). Specific emotional patterns (e.g., feeling pride) are associated with leading positions while other patterns (e.g., appreciate) are perceived being linked to subordinated

positions (Tiedens et al., 2000). Furthermore, there are different factors predicting emotions depending on the status within an organization: e.g., subordinates breaking the rules is mostly a predictor for anger in persons with leading positions, while perceived unfair treatment often leads to anger in subordinated persons (Fitness, 2000). There is also evidence for the influence of some job characteristics on positive affective experiences (e.g., autonomy in tasks is related to positive affects) (Saavedra and Kwun, 2000). Regarding differing research activity patterns of different career stages in academia, it is conspicuous, that research on emotional status in academia as organization is rare and, especially, research on the effect of the academic position on emotional experiences is lacking. However, based on previous findings on differences in emotional experiences between employees in different positions within the organization in other contexts and findings on differences in research activities between academic positions, we assume that the academic position held by the researcher affects emotional experiences.

Emotional experiences in academia

During the COVID-19 pandemic, precarious circumstances for teaching and researching in academia made the relevance of emotional states and mental health of academic staff more obvious (Tran et al., 2021). The study of Tran et al. (2021) focused the emotional state of the academic staff on a broader level without concrete emotion theories as basis. Researching in academia is highly competitive and, thus, complex because it includes several tasks [e.g., networking, collaborating, managing, doing, publishing research (Kyvik, 2013)]. Due to the complexity of research, the question arises how the emotional state of researchers can be captured efficiently and in more detail.

Research on emotions distinguishes between basic emotions and emotions in specific contexts. Tracy and Randles (2011) state that basic emotions, such as fear, anger, or happiness, are a small number of separated emotions that arise in the presence of certain stimuli, which result in neurological and physical expressions that can be found across cultures. Furthermore, basic emotions have a motivational component and are universal. Basic emotions are crucial factors in cognitive and behavioral processes. However, in complex situations, basic emotions interact with each other resulting in more complex emotional experiences and behavioral patterns (Tracy and Randles, 2011). For capturing very complex situations, basic emotions fall short. Pekrun (2006) defined specific achievement emotions describing emotional experiences in situations when individual's achievement count. Since competition and pressure to perform characterize research in academia, academic research can be defined as an achievement situation. Thus, achievement emotions (Pekrun, 2006) are relevant constructs to gauge

affective experiences during research. In the context of higher education, there is already evidence for the relevance of achievement emotions in educational contexts prior to scientific careers of doctoral graduates (e.g., undergraduate degree programs) (Pekrun and Stephens, 2010). Furthermore, emotional experiences are relevant for academic achievement and progress: previous studies provided evidence for the impact of achievement emotions on various factors such as achievement (Staw et al., 1994; Weiss and Cropanzano, 1996; Pekrun, 2006; Peixoto et al., 2016; Pekrun et al., 2017; Shao et al., 2020; Forsblom et al., 2021), motivation (Pekrun, 2006; Vandercammen et al., 2014; Løvoll et al., 2017), and well-being (Deci and Ryan, 2000; Pekrun, 2006). Achievement, motivation and well-being resulting from positive emotional experiences can be assumed as basis for scientific progress because only motivated, mentally healthy researchers are able to make scientific achievements and to contribute to scientific progress.

There are two types of achievement emotions: activity-related and outcome-related achievement emotions. Activity emotions arise during achievement situations (e.g., research activities) while outcome emotions are related to the achievement outcome (e.g., a published paper). Here, we focus on activity-related achievement emotions to capture emotional experiences of researchers during their research tasks because activity-related emotions directly reflect how researchers feel while conducting research. Pekrun defines four activity emotions: enjoyment, anger, frustration and boredom (Pekrun, 2006).

Individuals feel enjoyment when a positive valued event occurs while they perceive a high level of control of the event (Pekrun, 2006, 2019). In academia, enjoyment may be experienced, e.g., during capturing data coinciding with previous assumptions. Pekrun (2006, 2019) assumes that a person feels anger when a negative valued event occurs and the person feels a high level of control of the event. In academia, researchers may be angry when, e.g., they realize during conducting a carefully designed experiment that the experiment leads to non-analyzable outcomes caused by errors in running the experiment. A person is frustrated when a positive valued event does not occur or a negative valued event occurs whereby a person has no control over it (Pekrun, 2006, 2019). Frustration in academia may arise, e.g., during revising a manuscript when scientists do not know how to improve their manuscript due to incomprehensible critic of journal reviewers and the revision fails. Finally, a person feels boredom if a non-valued event does or does not occur whereby it does not matter if the person perceives a high or a low level of control about the event (Pekrun, 2006, 2019). Related to research activities, listening to an oral presentation during a conference, which is unexpectedly not associated to their own research interests, can trigger boredom of researchers.

Research on emotional experiences in the context of academia is rare, but previous research emphasized the relevance of emotions for mental health and preventing burnout in academia (Tran et al., 2021). The construct of achievement emotions (Pekrun, 2006, 2019) seems to be appropriate to efficiently describe emotional experiences in the highly competitive context of academic research. Although, there are already measurements on achievement emotions in higher education contexts [e.g., the Achievement Emotions Questionnaire (AEQ) on achievement emotions of university students (Pekrun et al., 2005, 2011)], measurements on achievement emotions in the specific context of academic research are lacking.

Supportive environment in academia through the lens of Self-Determination Theory

Emotions do not come out of the blue but are caused by antecedents (e.g., Pekrun, 2006, 2019; Tracy and Randles, 2011). Several environmental factors predict experienced achievement emotions (Pekrun, 2006, 2019), including support of autonomy, feedback on achievement, and the groups in which the persons are embedded (Pekrun, 2019; Pekrun et al., 2019). For capturing the complexity of social environmental influences on emotional experience in academia, it seems to be helpful to characterize these influences using Self-Determination Theory (SDT). SDT states that supporting three basic psychological needs (need for autonomy, competence, and social relatedness) is necessary for positive emotional experiences (Deci and Ryan, 2012). There is already evidence for the effect of strengthening basic needs through the social environment on achievement emotions (joy and boredom) in the context of 8th and 9th graders in school (Flunger et al., 2013).

SDT defines the *need for competence* as the need for experiencing success or feeling able to learn from failure and extend previous abilities (Vansteenkiste et al., 2020). In academia, doing research is an achievement situation determined by competition. Researchers compete in long qualification phases (doctoral studies, post-doctoral phase, junior professorship or similar), in which they have to prove themselves. In this context, feedback and encouragement from supervisors or colleagues is important to support the need for competence. Thus, doing, managing and publishing research is always bound up with evaluation (Kyvik, 2013), which may satisfy or thwart researchers' need for competence depending on how this evaluation is delivered and interpreted and, consequently, influence their emotions.

Individuals are satisfied in their *need to feel autonomous* when they are able to act, think and feel like themselves and in line with their attitudes and values (Vansteenkiste et al., 2020). In the academic context, autonomy is a central value (Henkel, 2005). Researchers work more or less autonomous on research questions of individual interest – taking into account

the relevance for and the interest of society in those questions. The extent to which they feel autonomous, consequently, affects their emotions during research.

SDT states, furthermore, that individuals *need to feel related to a group* of other individuals (e.g., Deci and Ryan, 2012). In the competitive context of science, researchers investigate increasingly complex research questions – consequently, collaborations between researchers become more and more important (Gläser, 2012). Kyvik (2013), accordingly, defines two central social facets of a researcher's role: networking and collaborating. Since exchange with other researchers in collaborative projects or during peer reviews become increasingly important, social relatedness to the scientific community is particularly relevant already during the doctorate (Meuleners et al., under revision). A researcher is typically associated to several scientific communities based on scientific interests and expertise (Kienle and Wessner, 2005). Scientific communities are dynamic while community-members refer to each other's scientific work and to a shared knowledge base of the specific research field (Kienle and Wessner, 2005; Gläser, 2012; Vekkaila, 2014).

Basically, SDT explains self-determined behavior based on the satisfaction of basic psychological needs. However, SDT comprises several further factors, which are influenced by these needs. There is empirical evidence for the effect of basic needs on motivation (e.g., Olafsen et al., 2018), scholarly identity, and career aspirations (Meuleners et al., under revision) as well as achievement emotions (Flunger et al., 2013). So far, SDT-research related to emotions focused mostly on emotion regulation (e.g., Roth et al., 2019; Benita, 2020), showing evidence for the influential effect of basic needs satisfaction on emotion regulation styles (e.g., Brenning et al., 2015; Benita et al., 2019). In the academic context, the variety of experienced specific positive and negative achievement emotions beyond regulating emotions is highly relevant for SDT-research because the emotional patterns may indicate potential for emotion regulation.

However, in academia, research on promoting supportive structures for professional development of academic staff focused mostly on doctoral studies and investigations on supportive structures in later career stages are still rare. Accordingly, there are already scales on basic needs support during the doctorate (van der Linden et al., 2018), while measurements on the three basic psychological needs tailored to the specific academic research context after doctoral graduation are lacking. But, policy demands for increasingly investigate such supportive structures in later career stages (European Science Foundation [ESF], 2012). Therefore, this study is aimed at closing this research gap by analyzing the perception of supportive structures of the social environment in relation to basic psychological needs and, thus, emotional experiences of the academic staff.

Research questions and hypotheses

We have argued that despite the fact that emotions are closely linked to scientific research because emotions are a necessary prerequisite for discovering new knowledge (Fischer et al., 2014), insights on the emotional state during research is lacking. Precarious conditions in academia during the COVID-19 pandemic emphasized the relevance of tracking the emotional state of academic staff as the emotional state is closely related to mental health and the prevention of burnout (Tran et al., 2021). Previous studies already support the linkage between emotions and the social environment (e.g., Flunger et al., 2013). However, we still know little about the role of need supportive structures for a positive emotional state in academia. Besides the influence of individual experiences of a supportive environment on emotions, structural characteristics are relevant for emotions as well. There is empirical evidence that differences in leading positions and subordinated positions in organizations influence emotional experiences (e.g., Fitness, 2000; Saavedra and Kwun, 2000; Tiedens et al., 2000; Sloan, 2004). However, research on emotional experiences in different positions in the specific organization of universities is lacking. This leads to the question, how academia can promote positive emotional experience patterns in different academic positions. Therefore, this study is aimed at analyzing the relationship between the perception of the professional context's need supportiveness in academia (perceived competence and autonomy support, social relatedness to the scientific community) and the emotional states of post-doctoral life scientists in Germany (enjoyment, anger, frustration, and boredom) in different academic positions (research assistants and PIs).

We suggest a predictive power of basic needs support on achievement emotions during daily research based on theoretical assumptions and empirical evidences: Basic psychological needs influence emotions (Deci and Ryan, 2012) and predictors in achievement emotions (autonomy support, achievement feedback and consequences, as well as integration in a community) coincide with the definition of basic psychological needs (need for autonomy, competence, and social relatedness) (Pekrun, 2006; Vansteenkiste et al., 2020). Furthermore, there is already empirical evidence for the effect of basic needs support on basic needs satisfaction as well as on emotions (Sheldon et al., 1996; Reis et al., 2000; Flunger et al., 2013; Olafsen et al., 2018). Competence confirmation is related to the emotional state: For example, positive feedback leads to positive emotions, e.g., enjoyment (Weiss and Cropanzano, 1996; Fisher and Ashkanasy, 2000). In professional contexts, feedback as a variant for competence support leads to positive affective experiences (Chaudhry et al., 2015). Therefore, it can be assumed that the need for competence is a relevant factor in academia for the prediction of emotions during research. Additionally, autonomy is a

relevant factor in the professional context with effects on affective experiences (Chaudhry et al., 2015). It can be assumed that there is a distinct need for autonomy in researchers related to emotional experiences. Previous research on the effect of basic needs on achievement emotions did not find a significant relationship between social relatedness and achievement emotions (joy and boredom) in the context of school (Flunger et al., 2013). Nevertheless, we include social relatedness to the scientific community due to evidences for the relevance of relationships in achievement situations predicting achievement emotions (Clem et al., 2020) and due to the relevance of networks to other scientists (e.g., in research collaborations) in the specific context of doctoral graduates in academia (Gläser, 2012; Kyvik, 2013). Consequently, we derive the following research question and hypotheses:

RQ 1: How does the degree of perceived supportiveness of the scientific context predict activity-related achievement emotions in the daily routine of doctoral graduates in the life sciences?

> *Hypothesis 1:* The degree of perceived supportiveness of the scientific context positively predicts the experience of *enjoyment* in life scientists.

(a) Perceived competence support in academia positively affects the experience of enjoyment. (b) Perceived autonomy support in academia positively affects the experience of enjoyment. (c) Social relatedness to the scientific community in academia positively affects the experience of enjoyment.

> *Hypothesis 2:* The degree of perceived supportiveness of the scientific context negatively predicts the experience of *anger* in life scientists.

(a) Perceived competence support in academia negatively affects the experience of anger. (b) Perceived autonomy support in academia negatively affects the experience of anger. (c) Social relatedness to the scientific community in academia negatively affects the experience of anger.

> *Hypothesis 3:* The degree of perceived supportiveness of the scientific context negatively predicts the experience of *frustration* in life scientists.

(a) Perceived competence support in academia negatively affects the experience of frustration. (b) Perceived autonomy support in academia negatively affects the experience of frustration. (c) Social relatedness to the scientific community in academia negatively affects the experience of frustration.

> *Hypothesis 4:* The degree of perceived supportiveness of the scientific context negatively predicts the experience of *boredom* in life scientists.

(a) Perceived competence support in academia negatively affects the experience of boredom. (b) Perceived autonomy support in academia negatively affects the experience of boredom. (c) Social relatedness to the scientific community in academia negatively affects the experience of boredom.

Furthermore, we are interested in the effect of different academic positions on achievement emotions during research. There is already evidence for the influence of the status within an organization on the acceptance of showing emotions (Tiedens et al., 2000; Sloan, 2004), different predictors of emotions in organizations (Fitness, 2000), and the relationship between job characteristics and positive affective experiences (Saavedra and Kwun, 2000). Based on different characteristics of conducting research for PIs (conducting independent scientific research) and research assistants (conducting limited independent scientific research) (Höhle and Teichler, 2016), we assume differences in emotional experiences due to the different career stages of PIs and research assistants. Here, we concentrate on academic careers after doctoral graduation. We focus on the academic position characterized through leadership responsibility (PI) or lack thereof (research assistant) in addition to a supportive environment as a job characteristic in post-doctoral research. These assumptions lead to the following research question and hypotheses:

RQ 2: Do researchers in different academic positions differ regarding their activity-related achievement emotions in daily research?

> *Hypothesis 5:* Researchers in academic positions with leadership responsibility (PIs) experience more *enjoyment* than researchers in academic positions without leadership responsibility (research assistants).

> *Hypothesis 6:* Researchers in academic positions with leadership responsibility (PIs) experience less *anger* than researchers in academic positions without leadership responsibility (research assistants).

> *Hypothesis 7:* Researchers in academic positions with leadership responsibility (PIs) experience less *frustration* than researchers in academic positions without leadership responsibility (research assistants).

> *Hypothesis 8:* Researchers in academic positions with leadership responsibility (PIs) experience less *boredom* than researchers in academic positions without leadership responsibility (research assistants).

However, both measurements on basic needs and on achievement emotions in the specific context of academic

research are lacking. Therefore, this study is further aimed at developing scales on perceived competence and autonomy support as well as on social relatedness within SDT tailored to the research context in academia. Additionally, this study is aimed at developing scales on research-related achievement emotions (enjoyment, anger, frustration, and boredom).

Materials and methods

Participants and procedures

The present study is part of the "E-Prom"-project that investigated influential factors on academic careers of doctoral graduates in the life sciences, funded by the German Federal Ministry of Education and Research (BMBF). In this paper, we present a subset of data collected in a cross-sectional study on doctoral graduates in the life sciences working at German universities in 2018. Invited participants were affiliated to one of 13 German universities that were selected as representative for different types of scientific locations in Germany, including both technical and non-technical as well as small and large universities. We invited all graduated life scientists at these 13 universities to answer an online-questionnaire. $N = 250$ graduated life scientists answered the questionnaire and provided answers to all items of scales relevant for this study (response rate was 5%). We excluded researchers in parental leave, working abroad, and non-academic staff. The subsample used in this article consists of 250 researchers, 38% male and 40% female researchers (22% did not answer this question). The surveyed life scientists were aged between 31 and 65 (mean ≈ 44 years; median = 41 years; mode = 41 years). The subsample includes mainly biologists (61%) and physicians (12%), the remaining 27% had a background in other fields within the life sciences (e.g., chemists, biochemists, biotechnologists, among others). The academic positions of the surveyed researchers ranged from research assistants to full professors, with 71% holding a position without leading responsibility (research assistants) and 29% being PIs.

Measures

The online-questionnaire contained various questions related to working conditions of life scientists. For the present study, we focus on their perceived competence support, perceived autonomy support, and social relatedness to the scientific community in the present employment at the university. Since fitted measurements on basic needs support in the academic research context after doctoral graduation are lacking, we newly developed such scales. For measuring perceived competence and autonomy support as well as social relatedness to the scientific community as one highly relevant

group in the academic context, we developed scales based on assumptions of SDT adapted to the specific academic context for ecological validity (Deci and Ryan, 2002; Vansteenkiste et al., 2020). The three scales on basic needs are analog to the scales in a previous study (Meuleners et al., under revision). In the previous study, the scales were phrased in the past questioning the experiences during the doctoral phase whereas the scales here were phrased in the present questioning the experiences in the current situation during research. Furthermore, we extended the scale on perceived autonomy support for improving the quality adding further five items—the scale in the previous study contained of three items while the scale in the present study included eight items.

Perceived competence support

The first scale measured in four items how the researchers perceive the support of their competence (α = 0.82). Here, the measurement focused on self-perceptions of the participants about the external support of the social environment for their competence. A sample item was "I'm always given the impression that I am making progress." The items were reported on a Five-Point-Likert-Scale from 1 (completely disagree) to 5 (completely agree).

Perceived autonomy support

To report the perception of autonomy support, participants answered an 8-item scale (α = 0.86). Again, the measurement focused on participant's self-perception about social environment's support for their autonomy. "I can always divide up my tasks on my own" was one sample item. The answer-scale ranged on a Five-Point-Likert-Scale from 1 (completely disagree) to 5 (completely agree).

Social relatedness to the scientific community

In a 6-item scale, we measured the perception of belongingness to the scientific community (α = 0.92). One sample item was "I feel like a member of my scientific community." The participants answered also on a Five-Point-Likert-Scale ranging from 1 (completely disagree) to 5 (completely agree).

Furthermore, we focus on researchers' activity-related achievement emotions (enjoyment, anger, frustration, and boredom) during their scientific work. Again, fitted measurements on achievement emotions in academic contexts after doctoral graduations are lacking. The four activity-related achievement emotions were measured with newly developed instruments that we adapted from the Achievement Emotions Questionnaire (AEQ) (Pekrun et al., 2005, 2011) tailored to academic contexts of doctoral graduates based on assumptions about achievement emotions. We adapted items of the AEQ on enjoyment, anger, frustration, and boredom to the research context staying as close as possible at the origin. We discuss and reconsider each item in a group of experts (doctoral graduates)

and non-experts (doctoral candidates) in the life sciences for improving the fit of our items for the special group of doctoral graduates researching in academia.

Activity-related enjoyment

Participants reported their enjoyment during researching on a 3-item scale (α = 0.83). One sample item was "I'm working in academia with enthusiasm." They answered on a Five-Point-Likert-Scale ranging from 1 (completely disagree) to 5 (completely agree).

Activity-related anger

On a 3-item scale, we examined the research-related anger (α = 0.76). One sample item was "I'm angry while doing scientific work." The answer-scale ranged on a Five-Point-Likert-Scale from 1 (completely disagree) to 5 (completely agree).

Activity-related frustration

To examine the frustration about research activities, participants answered a 2-item scale (α = 0.61). One sample item was "While researching, I'm frustrated." Participants answered on a Five-Point-Likert-Scale ranging from 1 (completely disagree) to 5 (completely agree).

Activity-related boredom

Participants reported their research-related boredom on a 3-item scale (α = 0.73). One sample item was "When researching, I'm without energy." They indicate their agreement on a Five-Point-Likert-Scale ranging from 1 (completely disagree) to 5 (completely agree).

Academic position

Finally, participants provided information on their academic position answering which academic position they held ("What is your current academic position at the university?"). They indicate their academic position as research assistant (including research assistants, academic councilor, and lecturer) or PI (including junior research group leader, junior professors, and full professors).

A full list of used items in the developed scales can be found at https://osf.io/pa852.

Data analysis

In a first step, we took a closer look at the factorial structure of our newly developed scales calculating confirmatory factor analyses on the three basic needs as well as on the four research-related achievement emotions. Second, to test our hypotheses, we calculated multiple linear regressions for each activity-related achievement emotion using SPSS 28. As predictors, we included the supportiveness of the

three basic psychological needs (perceived autonomy and competence support and social relatedness) and the academic position (PI, research assistant) held by the researchers, using forced entry (Field, 2009). Preliminary examinations for multiple linear regression as demanded by Field (2009) yielded approximate linear relationships between predictors and achievement emotions as criterions, no multicolinearity of the predictors (Tolerance > 0.10, VIF < 10, and average VIF $\approx$ 1), and homoscedasticity (White-tests, p > 0.05). Furthermore, the criterion of conditional expectation, meaning the average error value is zero for every value of the predictor variables is met in our analysis. However, the interval-scaled criterions (achievement emotions) are not normally distributed (Shapiro–Wilk test, p < 0.05) (Shapiro and Wilk, 1965). Consequently, we calculated multiple linear regression using bootstrapping for addressing non-normal distribution (Pek et al., 2018). We used regression analysis to make statements about the predictions (Rasch et al., 2006).

Results

In the following sections, we give a brief overview about the descriptive results. Before reporting the results of the multiple linear regressions, we present tests for group differences.

Descriptive results

Table 1 gives an overview of the descriptive statistics of the variables, reporting scale means, standard deviations, minimal and maximal responses within the Five-Point-Likert-Scale for coherence with the sections on measurements, Cronbach's alpha (α), and the number of scale items (N_{items}). Scale means for perceived competence support, perceived autonomy support, and social relatedness to the scientific community are close to the center of the Likert-Scale. Cronbach's alpha values between 0.85 and 0.92 indicate satisfactory scale reliabilities (Neuhaus and Braun, 2007). Regarding the achievement emotions,

TABLE 1 Overview of descriptive statistics.

Variables	M (SD)	Max	Min	α	N_{items}
1. Perceived competence support	3.13 (0.95)	5	1	0.85	4
2. Perceived autonomy support	3.67 (0.70)	5	1	0.86	8
3. Social relatedness to the scientific community	3.43 (0.92)	5	1	0.92	6
4. Enjoyment	3.95 (0.79)	5	1	0.83	3
5. Anger	1.62 (0.70)	5	1	0.76	3
6. Frustration	2.24 (0.92)	5	1	0.61	2
7. Boredom	1.47 (0.63)	4	1	0.73	3

Means (M), standard deviations (SD), minimal (Min) and maximal responses (Max), Cronbach's alpha (α), and the number of items (N_{items}).

enjoyment's scale mean is close to the center of the Likert-Scale, too, showing an adequate variance in participant's answer patterns. The frustration's scale mean is a bit lower (2.24). In contrast, scale means of the remaining negative research-related achievement emotions of anger and boredom are visibly lower (between 1.47 and 1.62). Nevertheless, Cronbach's alpha values between 0.61 and 0.83 indicate still satisfactory scale reliabilities (Neuhaus and Braun, 2007).

The confirmatory factor analysis on the newly developed scales on perceived competence and autonomy support as well as on social relatedness to the scientific community shows that all items can be separated properly in three factors representing the hypothesized scales (loadings ranging from |0.42| to |0.93|, average loading of |0.76|). The three-factor solution explains 63.0% of variance. Furthermore, we investigate the factorial structure of the newly developed scales on the research-related achievement emotions enjoyment, anger, frustration, and boredom. In a confirmatory factor analysis of all items, the four achievement emotions cannot be separated accurately. The low scale means for anger and boredom indicate a poor variance in the answers of the participants–most researchers do not feel anger or boredom during their research activities at all. Additionally, anger and boredom cannot be separated properly in factor analysis. Therefore, it seems not to be expedient to analyze the effect of the social environment (perceived competence support, perceived autonomy support, and social relatedness to the scientific community) on these negative achievement emotions. We exclude these two emotions from the following analyzes. Excluding one item of the frustration scale (item 9), factor analysis of the items on enjoyment and frustration shows that these two emotions can be separated properly. Here, two factors can be separated (loadings ranging from |0.69| to |0.91|, average loading of |0.82|). The two-factor solution explains 74.4% of variance. In summary, the following analyzes include perceived competence and autonomy support, social relatedness to the scientific community, enjoyment, and frustration.

The results in the correlation matrix of the five investigated variables (see Table 2) outline already the relevance of a need supportive environment and of the academic position regarding

life scientists' achievement emotions. Perceived supportiveness for the needs of competence, autonomy, and social relatedness to the scientific community correlate positively with enjoyment during research and negatively with frustration. Furthermore, the academic position correlates positively with enjoyment and negatively with frustration.

Test for group differences

Before conducting multiple linear regressions, we controlled for differences between possibly relevant subgroups within our sample. First, we compared male and female life scientists because of previous empirical evidence for the impact of gender on emotions (Shields, 2000; Fischer et al., 2004; Pekrun, 2006; Frenzel et al., 2007; Brescoll and Uhlmann, 2008; Kelan, 2008) and the relevance of gender differences in scientific productivity (Lindahl et al., 2021). We calculated a t-test to check gender-related differences of the measured achievement emotions showing no significant differences [$t_{enjoyment}(193) = 0.451$, $p = 0.652$; $t_{frustration}(193) = -1.375$, $p = 0.171$]. Second, we compared different fields within the life sciences (biology, medicine, and other fields) conducting univariate analysis of variance showing no significant differences [$F_{enjoyment}(3) = 0.862$, $p = 0.461$; $F_{frustration}(3) = 1.408$, $p = 0.241$]. Therefore, we do not report the results of the tests for group differences, but report results of the complete sample.

Multiple linear regression

We calculated two multiple linear regression analysis for the prediction of each activity-related achievement emotion using perceived supportiveness for competence, autonomy, social relatedness to the scientific community, and the academic position (see Table 3). The academic position was coded as dummy variable (PI = 1, research assistant = 0). In the following, we report the results of our analysis separated for each emotion (enjoyment and frustration).

To explain the perceived *enjoyment* during academic activities, we computed a multiple linear regression. We tested the association of perceived competence and autonomy support, social relatedness to the scientific community, and the academic position for explaining the positive activity-related achievement emotion enjoyment. The tested multiple linear regression model turned out to be significant [$F(4,245) = 21.351$, $p < 0.001$]. The four predictors together explain approximately 25% of the variance of enjoyment ($R^2 = 0.246$, $p < 0.001$). The effect size of $f^2 = 0.33$ showed a medium effect (Cohen, 1992). All four predictors, perceived competence support ($\beta = 0.21$, $p < 0.001$), perceived autonomy support ($\beta = 0.27$, $p = 0.002$), social relatedness to the scientific community ($\beta = 0.21$, $p < 0.001$), and

TABLE 2 Correlation matrix for the investigated variables of basic needs support and achievement emotions.

Variables	1	2	3	4	5
1. Perceived competence support					
2. Perceived autonomy support	**0.49*****				
3. Social relatedness to the SC	0.07	0.10			
4. Enjoyment	**0.35*****	**0.35*****	**0.30*****		
5. Frustration	**−0.23*****	**−0.26*****	**−0.13****	**−0.51*****	
6. Academic position	0.02	0.09	**0.35*****	**0.26*****	−0.11

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Significant correlations are highlighted in bold.

TABLE 3 Results of multiple linear regressions predicting researcher's activity-related achievement emotions (enjoyment and frustration) by perceived competence support, autonomy support, social relatedness, and the academic position ($N = 250$).

Criterion	Predictors	β	b (SE)	T	p	R^2
Enjoyment	Intercept		1.8 (0.28)	6.602	<0.001	**0.25** (p < 0.001)
	Perceived competence support	**0.21**	0.19 (0.05)	3.609	<0.001	
	Perceived autonomy support	**0.27**	0.23 (0.07)	3.194	0.002	
	Social relatedness	**0.21**	0.18 (0.05)	3.535	<0.001	
	Academic position	**0.17**	0.30 (0.10)	2.902	0.004	
Frustration	Intercept		3.83 (0.35)	10.851	<0.001	**0.08** (p < 0.001)
	Perceived competence support	**−0.14**	−0.14 (0.07)	−1.990	0.048	
	Perceived autonomy support	**−0.18**	−0.24 (0.09)	−2.582	0.010	
	Social relatedness	−0.07	−0.07 (0.07)	−1.144	0.254	
	Academic position	−0.08	−0.15 (0.13)	−1.171	0.243	

Significant relationships are highlighted in bold. Academic position was coded as dummy variable (PI = 1 and research assistant = 0).

the academic position (β = 0.17, p = 0.004), were significantly associated with enjoyment during research. Perceived autonomy support had the highest effect.

Second, we investigated the association of *frustration* with the perceived support for autonomy, competence, and social relatedness to the scientific community and the academic position. The tested regression model was significant [$F(4,245)$ = 6.710, $p < 0.001$]. Approximately 8% of variance in frustration was explained in a multiple linear regression by perceived support of the three basic psychological needs and the academic position [$R^2 = 0.084, p < 0.001$]. This was a weak effect ($f^2 = 0.09$, Cohen, 1992). However, only perceived competence support (β = −0.14, p = 0.048) and perceived autonomy support (β = −0.18, p = 0.010) were significantly associated to frustration. The effect of social relatedness (β = −0.07, p = 0.254) and the academic position (β = −0.08, p = 0.243) on frustration was not significant. Again, perceived autonomy support was associated to frustration with the highest effect.

Discussion

This study is aimed at investigating the perceived supportiveness of the social environment in academia during research and the academic position for explaining emotional states of graduated life scientists. Therefore, we analyzed two research questions. Regarding the first research question on how does the degree of perceived supportiveness of the scientific context predict activity-related achievement emotions in daily research of German life scientists, the results of this study show that the perception of supporting basic psychological needs (need for competence, need for autonomy) and being socially related to the scientific community are significantly related to achievement emotions during research (enjoyment, frustration). High levels in (a) perceived competence and (b) perceived autonomy support as well as in (c) social

relatedness to the scientific community are associated with high levels in enjoyment during academic activities of German life scientists (supporting hypothesis 1). Low levels in (a) perceived competence and (b) perceived autonomy support also imply high levels in frustration (supporting hypothesis 3). Surprisingly, in investigating research-related frustration, social relatedness to the scientific community seems not to be relevant (contradicting hypothesis 3c). This means, that researchers who perceive themselves as being supported in their needs of competence and autonomy and being integrated in the scientific community experience more enjoyment during their research-related activities than researchers without this support. In addition, life scientists who perceive themselves as being supported in feeling competent and autonomous experience less frustration compared to researchers without this support. In sum, perception of supportive environments in life science academia are associated with more experienced positive emotions and less experienced negative emotions while the role of specific needs differs for each emotion. Since we needed to exclude both results on anger and boredom because the scales did not differentiate these emotional experiences during research accurately enough, hypotheses 2 and 4 cannot be further investigated.

Regarding the second research question whether researchers in different academic positions in the life sciences differ in their experienced achievement emotions, the academic position held by the life science researchers is significantly associated to emotional experiences during research. PIs with leading responsibilities experience more enjoyment (supporting hypothesis 5) than research assistants without leading responsibilities. Meanwhile, there are no significant differences in experienced frustration depending on the academic position (contradicting hypothesis 7). This means, higher academic positions in the life sciences come with a more favorable emotional experience pattern. Again, hypotheses 6 and 8 cannot be

further investigated because we needed to exclude anger and boredom from analyzes.

Career steps toward more leadership responsibility, thus, are not only the next necessary career steps in competitive academia (Kwiek and Antonowicz, 2015), but also seem to come with a more positive emotional experience of research in the life sciences. Additionally, perception of supportive contexts in academia seem to be beneficial for satisfying basic psychological needs and, thus, for favorable emotional patterns, which previous research has shown to promote well-being, motivation, and achievement (e.g., Deci and Ryan, 2000; Pekrun, 2006; Shao et al., 2020; Forsblom et al., 2021). These previous studies in other contexts, already provided empirical evidence for the impacts of emotions on well-being, achievement and motivation (e.g., Deci and Ryan, 2000; Pekrun, 2006; Shao et al., 2020; Forsblom et al., 2021), thus, further positive effects of emotions can be assumed in this academic context as well. Nevertheless, further research on the effects of emotions in post-doctoral research is needed. With academic achievements further scientific progress can be promoted. Consequently, our results give a hint that it may be worthwhile to explicitly foster supportive academic environments and promote advancement opportunities in life science academic careers, first of all to foster pleasant emotional research experiences, and in the end also better research achievements. The findings of this study lead to some further theoretical and practical implications outlined in the following sections.

Theoretical implications

The results of our study on the role of perceived support of competence and autonomy as well as social relatedness to the scientific community in emotional experiences during life science research in Germany support general assumptions of SDT (Deci and Ryan, 2012). Beyond the national and field-specific context, our results give a hint for other contexts since our results are in line with SDT assuming universal validity of basic needs (Vansteenkiste et al., 2020). Furthermore, our findings in German life sciences coincide with previous empirical studies on the effect of basic needs on emotional experiences showing significant positive relations between satisfied needs for competence, autonomy, and social relatedness and positive emotions and a negative effect of competence satisfaction on negative emotions (Sheldon et al., 1996; Reis et al., 2000). However, these previous studies did not differentiate between specific emotions. Findings of our study provide a more differentiated perspective on the relationship between basic needs and specific positive (enjoyment) and negative emotions (frustration) explained in the following sections for each basic need.

Positive effects of perceived supporting the *need for competence* on the positive emotion enjoyment as well as negative effects on the negative emotion frustration in German life science post-doctoral research are in line with previous findings of SDT (e.g., Sheldon et al., 1996; Reis et al., 2000). However, our results on specific positive (enjoyment) and negative emotions (frustration) extend insights of previous studies (e.g., Sheldon et al., 1996; Reis et al., 2000). Furthermore, our results give a hint on the negative role of perceived competence support in frustration experiences in life science research beyond effects on joy and boredom in school contexts (Flunger et al., 2013). Our results suggest that supporting competence in life science academic research can be beneficial for enjoying research activities and lessen frustrative research experiences. In sum, we assume that supporting the need for competence seems to be highly important for promoting a favorable emotional pattern during research in the life sciences.

In line with assumptions of SDT on the effect of basic needs on emotions (Deci and Ryan, 2012), we found a positive relationship between *social relatedness* to the scientific community and enjoyment in German life science research. These findings contradict previous findings suggesting no significant effect of relatedness on achievement emotions of joy and boredom (Flunger et al., 2013). The contrast between findings of Flunger et al. (2013) and our findings are probably based on differences between the samples: Flunger et al. (2013) investigated students (8th and 9th grade) whereas we look at doctoral graduates. Particularly, doing research is highly associated with meaningful collaborative work (Gläser, 2012; Kyvik, 2013), thus, it can be assumed that social relatedness is relevant for explaining emotional experiences in research settings. Surprisingly, we found no significant relationship with frustration when being embedded in a network with other researchers. Social relatedness to scientific communities is a rather important factor in scientific research (e.g., in collaborative research) (Gläser, 2012; Kyvik, 2013). Especially in the life sciences, collaborative research is highly relevant (e.g., biologists and physicians researching together for developing new vaccines). However, working in collaborative research teams could probably also exhaust researchers because some collaboration partners are hard to work with, e.g., when they do not complete tasks in the expected quality or time. Consequently, our missing relationship between social relatedness and frustration in life science research is surprising. Nevertheless, this field-specific finding gives a hint for other contexts based on the assumed universality of the investigated variables (Pekrun, 2019; Vansteenkiste et al., 2020). Different types of emotion regulation could lead to the missing relationship between social relatedness to scientific communities and frustration because some scientists may reduce their frustration through communication about frustrating events with members of their scientific communities while other scientists may not use their communities for reducing research-related frustration. Further qualitative studies on emotion regulation during research could

investigate these links in more detail. Implications based on our results on the relationship between basic needs and achievement emotions in the context of academic research are limited because theory on achievement emotions was developed for earlier academic contexts (school, bachelor and master studies) (Pekrun, 2006; Pekrun and Stephens, 2010) linked to learning communities. In academic research, scientific communities as communities of practice (Kienle and Wessner, 2005) are relevant groups. This slightly different context, may be a reason for the missing effect on frustration and the difficulties in gauging some achievement emotions in this research context (especially anger and boredom). Further research on achievement emotions in the specific context of academic research is needed. Furthermore, it should be considered that scientific communities as communities of practice (Kienle and Wessner, 2005) in other countries and contexts may be defined by different structures and conditions of research. Thus, further research in other countries and other contexts could be beneficial for comparing our results based on a German life science sample.

Perceived support of the *need for autonomy* is associated to every respective achievement emotion in the expected way: Perceived autonomy support fosters enjoyment and reduces frustration in German life scientists. This finding supports assumptions derived from both SDT (Deci and Ryan, 2012) and research on achievement emotions (Pekrun, 2006). The effect of perceived autonomy support on the two achievement emotions extends previous findings on the positive relation between autonomy satisfaction and positive emotions in general (Sheldon et al., 1996; Reis et al., 2000) and extends empirical evidence for the effect of autonomy satisfaction on joy and boredom in particular (Flunger et al., 2013), adding new insights for a negative effect on frustration. In sum, perceived autonomy support seems to be a crucial factor in emotional experiences, which can be explained by the match between the definition of the need for autonomy [autonomous activities coinciding with own wishes and values (Vansteenkiste et al., 2020)] and the leitmotif of independent scientific research (Henkel, 2005).

In sum, separately investigating specific emotions indicates a complex relationship pattern between basic needs and emotional experiences in life science academia. Results of this study give a hint on the potentially adequacy of investigating achievement emotions in late stages of higher education, looking at post-doctoral research in academia. Furthermore, our results support benefits of a more detailed investigation on the impact of basic needs on specific emotions in SDT-research as previous research already hinted (e.g., Flunger et al., 2013). This leads to potentially further scopes of application for SDT and achievement emotions. In other contexts, like school and undergraduate education where both SDT and achievement emotions were already applied separately (e.g., Pekrun, 2006; Pekrun and Stephens, 2010; Goodman et al., 2021; Jeno et al., 2021; McLennan et al., 2021) combined

investigations of basic needs support and achievement emotions could be beneficial.

Results of our study on the positive association of the *academic position* to experienced enjoyment during life science research suggests that leading responsibilities are associated with more favorable emotional patterns when doing research. The significant effect of the academic position supports previous assumptions that academic activities differ between PIs and research assistants (Höhle and Teichler, 2016). Beyond previous findings on varying acceptance of emotion expressions (Tiedens et al., 2000; Sloan, 2004), different predictors of emotions (Fitness, 2000), and the impact of characteristics in employment on positive affective experiences (Saavedra and Kwun, 2000) depending on the status within organizations, we found evidence for a positive relationship between leading positions in German universities and specific research-related achievement emotions. The more positive emotional experience of research for PIs could be based on the characteristics of their employment: most PIs conduct independent scientific research holding a permanent position or having a permanent position in prospect (Höhle and Teichler, 2016). A secure employment and the opportunity in doing independent research may facilitate a more positive emotional experience of research in German life sciences. Since academic positions prior to PIs in academia are internationally often associated with more insecurity in employment (e.g., Teichler et al., 2013), our national results give a hint for the emotional state in other countries as well. Besides our findings on the association of a supportive environment on positive emotional experiences, these findings give a hint that scientific progress of academic achievement can also be fostered by secure employments and the possibility to research independently via emotional experiences (e.g., Pekrun, 2006; Shao et al., 2020; Forsblom et al., 2021). Here, it should be considered, that there might be other structural and individual factors influencing positive emotional experiences during research (e.g., pleasant working atmosphere, good work-life-balance, general job satisfaction). However, the academic position did not affect perceived levels of frustration during research. Both, leading researchers and research assistants are frustrated during their research activities in comparable ways. Beyond this first hint on similar levels of frustration for PIs and research assistants in German life sciences, further research on specific reasons for frustration could shed a more detailed light on experienced frustration in the different academic positions based on varying position characteristics (e.g., Höhle and Teichler, 2016). Beyond our results another hypothesis explaining our findings could be raised. Further research could investigate if scientists with more perceived enjoyment regarding research are more likely to pursue an academic career and, thus, are more likely to be found in leading academic positions.

Practical implications

Besides theoretical implications, findings of this study on German life scientists give a hint for further practical implications maybe beneficial to foster positive emotional experiences, to reduce negative emotional experiences during research and, thus, to engage achievement, well-being, and mental health in general academia (Pekrun, 2006; Tran et al., 2021) based on the assumed universality of the investigated variables (Pekrun, 2019; Vansteenkiste et al., 2020). Our results suggest that mainly perceived *support of autonomy* through the academic environment is associated with higher levels of enjoyment and lower levels of frustration. Consequently, based on the evidence for the opportunity to foster positive achievement emotions (Hößle et al., 2019) support of autonomy should be extended. Colleagues and supervisors could integrate researchers without leadership positions in decision-making processes and give scope to action regarding research (developing research questions, determining research designs, evaluating data) and research funding (raising external funds) to foster self-determined research. However, most PIs have already freedom of choices on research-related activities (Höhle and Teichler, 2016), thus, academic environment should primarily support autonomy in research assistants. However, PIs can be supported in their experienced autonomy as well through less restrictive demands of external funders and university administration. The whole group of researchers could benefit from being supported in their autonomy in open science. Researching in open science means that scientific communities share and develop transparent and accessible knowledge in collaborations (Vicente-Saez and Martinez-Fuentes, 2018). After replication crisis in psychological research researching in the framework of open science (Brachem et al., 2022) enables researchers to conduct research increasingly self-determined and autonomous because it initially reduced restrictive attitudes of scientific communities against non-significant research results.

Furthermore, perceived *support of competence* through the academic environment is linked to higher levels of enjoyment and lower levels of frustration. Consequently, promoting competence support, researchers should develop constructive way to handle errors. Since a culture of learning from errors is useful in educational contexts (Meyer et al., 2006; Spychiger et al., 2006) as well as in organizations (Schüttelkopf and Vogl, 2015), it may especially be important in scientific research. In addition, colleagues and supervisors should be encouraged to give feedback on research because feedback in other educational contexts is highly relevant (Wisniewski et al., 2020). In academia, colleagues and supervisors could give feedback with a focus on further career development opportunities for the respective other researcher. Previous research suggests that feedback is relevant for further career

development in organizations (van der Rijt et al., 2012). Another possibility would be to increase the recognition of research achievements in research teams, e.g., by presenting published, non-published and even non-significant research results within the team. Non-published and non-significant research is interesting and an achievement of employees that should be recognized especially in research fields of the life sciences (Buhl-Mortensen and Wellin, 1998). Researching in open science sharing research designs, results, methods, among others (Watson, 2015; Vicente-Saez and Martinez-Fuentes, 2018) is one way supporting the competence of the academic staff. Both, PIs and research assistants could benefit from support of their need for competence because learning is a lifelong process (Fischer, 2000; Field, 2010).

Lastly, *social relatedness* to the scientific community is associated with higher levels of enjoyment. Consequently, academia should foster opportunities to develop relationships with other scientists with similar research interests, e.g., through fostering conference visits, research cooperation, and resulting cooperative research publications (Ebner and Reinhardt, 2009; Dimitrious et al., 2014; Jarvis et al., 2020). Especially during the COVID-19 pandemic, the relevance of physical presence at scientific conferences got apparent because many conferences were canceled or replaced by digital forms (Consortium for the National Report on Junior Scholars [BuWiN], 2021). However, imitating in-person events through digital tools is hardly possible and digitalization of conferences hampers informal personal communication, inspiration, and building long lasting networks (Jarvis et al., 2020). Researchers in every academic stage benefit from being embedded in a sufficient group of scientists because networking and collaboration are central aspects of academic activities (Kyvik, 2013; Sarabipour et al., 2020). Previous research provided evidence that scientists in all career stages benefit from personal communications during scientific conferences for further scientific collaborations (Eberle et al., 2021).

Beyond effects of the social environment in academia, leading academic positions (PI) are positively associated with higher levels of enjoyment. However, they are not associated with levels of frustration. Consequently, academia could further implement more permanent positions and positions with a permanent position in prospect to foster motivational and successful research (Pekrun, 2019). Higher numbers of permanent positions are still needed as is often criticized on national levels, e.g., in Germany where our study participants were located (Krempkow et al., 2014; Consortium for the National Report on Junior Scholars [BuWiN], 2021). Some projects for implementing further permanent positions have already started. In Germany, one approach for fostering more secure academic positions is establishing tenure-track-professorship positions (Consortium for the National Report on Junior Scholars [BuWiN], 2021). However, this project is

still ongoing (Joint Science Conference [GWK], 2016). Based on our results, further projects could be initiated to create more secure working conditions for independent research below permanent professorship positions to foster positive emotions during research. There are already demands for strengthening academic mid-level faculty (e.g., Jaksztat et al., 2010; Holderberg, 2020) that could be further developed to facilitate positive emotional patterns during research and, consequently, academic achievements and scientific progress. However, it should be considered, that there could be another hypothesis explaining our findings: scientists with a positive emotional pattern with high levels of enjoyment could be more likely to stay in academia. This leads to further research demands on longitudinal investigations explained in the following section.

However, reducing negative emotional experiences does not imply that negative achievement emotions should entirely disappear (e.g., anger as physiologically activating emotion could lead to new strategies of action). Nevertheless, levels of frustration should be reduced because this negative activity-related achievement emotion is deactivating and does not activate new cognitive processes. Whereas, high levels of enjoyment should be fostered. As a positive activity-related achievement emotion, enjoyment is physiologically activating and could lead to better focusing on tasks, to inducing interest and intrinsic motivation, and to the flexible usage of strategies of action (Pekrun, 2019).

Limitations and future research

Some limitations of our study need to be taken into account. First, changing academic activities and obligations regarding the academic positions held by the participants complicate measuring the perceived support of the basic psychological needs of competence and autonomy and measuring social relatedness as well as the achievement emotions (enjoyment, anger, frustration, and boredom). Nevertheless, we gauged perceived support of competence, autonomy, and social relatedness to the scientific community as well as the achievement emotions on a broader level. We are confident that the used scales apply to both academic positions of PIs and research assistants supported by satisfying scale reliability (see **Table 1**). However, gauging the affective variables using scales on a broader level could also be unfavorable because these scales might not capture reality in research in sufficient detail. This leads to further research on the association of basic needs supportive environments on achievement emotions during research. Second, the used scales were newly developed by the authors and not yet validated. Nevertheless, objectivity, satisfactory reliability and separability of the scales on the basic needs are met. Regarding the scales on research-related achievement emotions, we needed to exclude the

scales on anger and boredom from further analyzes based on missing variance. However, objectivity, satisfactory reliability and separability of the remaining scales on enjoyment and frustration in factor analyses are met. Further research on the used scales comparing our results with already existing scales on basic needs support during the doctorate (van der Linden et al., 2018) and on achievement emotions in university students (AEQ, Pekrun et al., 2005, 2011) is necessary. Furthermore, scales on research-related anger and boredom should be refined and tested for the special context of post-doctoral research. Here, sufficient gauging low levels of boredom and anger during research should be considered in further research (e.g., anger in specific research-related situations could be examined considering, e.g., anger during review processes based on incomprehensible criticisms of a manuscript). Third, our results are based on a German sample of graduated life scientists. However, we are confident that our findings apply to an international context and are relevant beyond the field of life sciences because we gauged the investigated variables of basic needs and achievement emotions on a broader level and both basic needs and achievement emotions are assumed to be universal (Pekrun, 2019; Vansteenkiste et al., 2020). This leads to a need for further research on the prediction of achievement emotions using basic psychological needs in other countries and research fields to compare our results. Lastly, our results are based on a cross-sectional correlational study of self-reports. Thus, assumptions about directionality and causality are limited. We derived directionality from theoretical assumptions. Furthermore, deriving practical implications is limited. This leads to a further need for research on longitudinal and interventional research designs on predicting and fostering achievement emotions in academia. Additionally, it could be useful for further research to integrate the individual perspective of scientists in qualitative studies.

Conclusion

Perceived supporting basic psychological needs for competence and autonomy as well as social relatedness during research in academia is associated with higher levels of positive activity-related achievement emotions of enjoyment and lower levels of the negative achievement emotion frustration. Surprisingly, social relatedness to the scientific community is not associated to frustration. Nevertheless, promoting researchers in feeling autonomous, competent, and socially related to other scientists is associated to a more favorable emotional pattern during research. Furthermore, leading academic positions are connected to more positive emotional experiences, which may explain researchers' well-being, mental health, academic achievement and scientific progress (e.g., Pekrun, 2006; Forsblom et al., 2021; Tran et al., 2021).

Data availability statement

Ethics statement

The studies involving human participants were reviewed and approved by Ethics committee of the Medical Faculty of LMU Munich (Ethics approval numbers: 368-14 and 19-332). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JM further developed part of the questionnaires as well as developed part of the questionnaires herself, processed the data for publication, statistically analyzed the data, designed the article, and wrote it in a leading role. JE and BN developed the study design, developed part of the questionnaires, assisted with data collection and interpretation, and contributed substantially to revising the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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References

Benita, M. (2020). Freedom to feel: a self-determination theory account of emotion regulation. *Soc. Personal. Psychol. Compass* 14:e12563. doi: 10.1111/spc3.12563

Benita, M., Kehat, R., Zaba, R., Blumenkranz, Y., Kessler, G., Bar-Sella, A., et al. (2019). Choosing to regulate emotions: pursuing emotion goals in autonomy-supportive and controlling contexts. *Personal. Soc. Psychol. Bull.* 45, 1666–1680. doi: 10.1177/01461672198385

Boyer, E. L. (1990). *Scholarship Reconsidered: Priorities of the Professoriate. the Carnegie Foundation for the Advancement of Teaching*. New York, NY: John Wiley and Sons.

Brachem, J., Frank, M., Kvetnaya, T., Schramm, L. F. F., and Volz, L. (2022). Replikationskrise, p-hacking und open science [Replication crisis, p-hacking and open science]. *Psychol. Rundschau* 73, 1–17.

Brenning, K., Soenens, B., Van Petegem, S., and Vansteenkiste, M. (2015). Perceived maternal autonomy support and early adolescent emotion regulation: a longitudinal study. *Soc. Dev.* 24, 561–578. doi: 10.1111/sode.12107

Brescoll, V. L., and Uhlmann, E. L. (2008). Can an angry woman get ahead? *Psychol. Sci.* 19, 268–275. doi: 10.1111/j.1467-9280.2008.02079.x

Buhl-Mortensen, L., and Wellin, S. (1998). The ethics of doing policy relevant science: the precautionary principle and the significance of non-significant results. *Sci. Eng. Ethics* 4, 401–412.

Chaudhry, I. S., Maurice, J. G., and Haneefuddin, M. (2015). Impact of job characteristics on employees emotions & work-related outcomes in Pakistan. *Int. J. Bus. Manag.* 10:233. doi: 10.5539/ijbm.v10n8p233

Chou, W.-Y., and Budenz, A. (2020). Considering emotion in COVID-19 vaccine communication: addressing vaccine hesitancy and fostering vaccine confidence. *Health Commun.* 35, 1718–1722. doi: 10.1080/10410236.2020.1838096

Clem, A.-L., Rudasill, K. M., Hirvonen, R., Aunola, K., and Kiuru, N. (2020). The roles of teacher-student relationship quality and self-concept of ability in adolescents' achievement emotions: temperament as a moderator. *Eur. J. Psychol. Educ.* 36, 263–286. doi: 10.1007/s10212-020-00473-6

Cohen, J. (1992). A power primer. *Psychol. Bull.* 112, 155–159. doi: 10.1037//0033-2909.112.1.155

Consortium for the National Report on Junior Scholars [BuWiN] (2021). *Bundesbericht Wissenschaftlicher Nachwuchs 2021: Statistische Daten und Forschungsbefunde zu Promovierenden und Promovierten in Deutschland [National report on young researchers 2021: Statistical data and research findings on doctoral candidates and doctoral graduates in Germany]*. Bielefeld: W. Bertelsmann Verlag.

Deci, E. L., and Ryan, R. M. (2000). The "What" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychol. Inquiry* 11, 227–268.

Deci, E. L., and Ryan, R. M. (2002). "Overview of self-determination theory: an organismic dialectical perspective," in *Handbook of Self-Determination Research*, eds E. L. Deci and R. M. Ryan (Rochester: The University of Rochester Press), 3–33. doi: 10.1111/bjhp.12054

Deci, E. L., and Ryan, R. M. (2012). "Self-Determination theory," in *Handbook of Theories of Social Psychology*, eds P. A. M. Van Lange, A. W. Kruglanski, and E. T. Higgins (Los Angeles, CA: SAGE), 416–437.

Dimitrious, N. K., Sakas, D. P., and Vlachos, D. S. (2014). Modeling publications in academic conferences. *Proc. Soc. Behav. Sci.* 147, 467–477. doi: 10.1016/j.sbspro.2014.07.139

Eberle, J., Stegmann, K., Barrat, A., Fischer, F., and Lund, K. (2021). Initiating scientific collaborations across career levels and disciplines: a network analysis on behavioral data. *Int. J. Comput. Supp. Collab. Learn.* 16, 151–184. doi: 10.1007/s11412-021-09345-7

Ebner, M., and Reinhardt, W. (2009). "Social networking in scientific conferences: twitter as tool for strengthen a scientific community," in *Conference Paper for Proceedings of the 1st International Workshop on Science 2.0 for TEL at the 4th European Conference on Technology Enhanced Learning (EC-TEL'09)*, (Paderborn).

European Commission [EC] (2011). *Towards a European Framework for Research Careers: Directorate General for Research & Innovation*. Brussels: European Commission.

European Science Foundation [ESF] (2012). *Developing Research Careers In and Beyond Europe: Enabling – Observing – Guiding and Going Global*. Strasbourg: ESF.

Field, A. (2009). *Discovering Statistics Using SPSS*, 3rd Edn. Los Angeles, CA: SAGE.

Field, J. (2010). "Lifelong learning," in *International Encyclopedia of Education*, 3rd Edn, eds P. Peterson, E. Baker, and B. McGaw (Amsterdam: Elsevier), 89–95.

Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., et al. (2014). Scientific reasoning and argumentation: advancing an interdisciplinary research agenda in education. *Frontline Learn. Res.* 4, 28–45.

Fischer, A. H., Rodriguez Mosquera, P. M., van Vianen, A. E. M., and Manstead, A. S. R. (2004). Gender and culture differences in emotion. *Emotion* 4, 87–94. doi: 10.1037/1528-3542.4.1.87

Fischer, G. (2000). Lifelong learning – more than training. *J. Interact. Learn. Res.* 11, 265–294.

Fisher, C. D., and Ashkanasy, N. M. (2000). The emerging role of emotions in work life: an Introduction. *J. Organ. Behav.* 21, 123–129.

Fitness, J. (2000). Anger in the workplace: an emotion script approach to anger episodes between workers and their superiors, co-workers and subordinates. *J. Organ. Behav.* 21, 147–162.

Flunger, B., Pretsch, J., Schmitt, M., and Ludwig, P. (2013). The role of explicit need strength for emotions during learning. *Learn. Individual Differ.* 23, 241–248.

Forsblom, L., Pekrun, R., Loderer, K., and Peixoto, F. (2021). Cognitive appraisals, achievement emotions, and students' math achievement: a longitudinal analysis. *J. Educ. Psychol.* 114, 346–367. doi: 10.1037/edu0000671

Frenzel, A. C., Pekrun, R., and Goetz, T. (2007). Girls and mathematics: a "hopeless" issue? a control-value approach to gender differences in emotions towards mathematics. *Eur. J. Psychol. Educ.* 22, 497–514.

Gläser, J. (2012). "Scientific communities," in *Handbuch Wissenschaftssoziologie*, eds S. Maasen, M. Kaiser, M. Reinhart, and B. Sutter (Wiesbaden: Springer Fachmedien Wiesbaden), 151–162. doi: 10.1007/978-3-531-18918-5_12

Goodman, R. J., Trapp, S. K., Park, E. S., and Davis, J. L. (2021). Opening minds by supporting needs: Do autonomy and competence support facilitate mindfulness and academic performance? *Soc. Psychol. Educ.* 24, 119–142. doi: 10.1007/s11218-020-09577-9

Henkel, M. (2005). Academic identity and autonomy in a changing policy environment. *Higher Educ.* 49, 155–176. doi: 10.1007/s10734-004-2919-1

Höhle, E. A., and Teichler, U. (2016). "Career and self-understanding of academics in Germany in comparative perspective," in *Biographies and Careers throughout Academic Life*, eds J. F. Galaz-Fontes, A. Arimoto, U. Teichler, and J. Brennan (Berlin: Springer), 241–270.

Holderberg, P. (2020). *Zur Beschäftigungssituation des akademischen Mittelbaus. Ergebnisse der dritten Befragung der wissenschaftlichen und künstlerischen Mitarbeiter_innen der Stiftung Universität Hildesheim [On the employment situation of academic and artistic staff. Results of the third survey of academic and artistic staff at the Foundation University of Hildesheim.]*. Hildesheim: Universitätsverlag Hildesheim.

Hößle, C., Stockinger, K., and Pekrun, R. (2019). "Promoting positive achievement emotions with a control-value intervention: findings from an initial evaluation study," in *Proceedings of the Conference Paper at the PAEPSY Conference*, Leipzig.

Jaksztat, S., Schindler, N., and Briedis, K. (2010). *Wissenschaftliche Karrieren. Beschäftigungsbedingungen, berufliche Orientierungen und Kompetenzen des wissenschaftlichen Nachwuchses [Scientific careers. Employment conditions, career orientations and competencies of young scientists.]*. Fulda: Hochschule.

Jarvis, T., Weiman, S., and Johnson, D. (2020). Reimagining scientific conferences during the pandemic and beyond. *Sci. Adv.* 6:eabe5815. doi: 10.1126/sciadv.abe5815

Jeno, L. M., Nylehn, J., Hole, T. N., Raaheim, A., Velle, G., and Vandvik, V. (2021). Motivational determinants of students' academic functioning: the role of autonomy-support, autonomous motivation, and perceived competence. *Scand. J. Educ. Res.* doi: 10.1080/00313831.2021.1990125

Joint Science Conference [GWK] (2016). *Bekanntmachung der Verwaltungsvereinbarung zwischen Bund und Ländern gemäß Artikel 91b Absatz 1 des Grundgesetzes zur Förderung des wissenschaftlichen Nachwuchses vom 19. Oktober 2016, Bonn [Announcement of the Administrative Agreement between the Federal Government and the States in accordance with Article 91b (1) of the Grundgesetz (German Basic Law) on supporting young scientists of October 19, 2016, Bonn]*. Bonn: Joint Science Conference.

Kelan, E. K. (2008). Emotions in a rational profession: the gendering of skills in ICT work. *Gender Work Organ.* 15, 49–71.

Kienle, A., and Wessner, M. (2005). "Principles for cultivating scientific communities of practice," in *Communities and Technologies 2005: Proceedings of the Second Communities and Technologies Conference, Milano 2005*, eds P. van den Besselaar, G. de Michelis, J. Preece, and C. Simone (Dordrecht: Springer), 283–300.

Krempkow, R. (2010). Wissenschaft oder Wirtschaft? Arbeitsmarkt und Perspektiven für Promovierte in Deutschland [Academia or industry? Labor market and prospects for doctoral graduates in Germany]. *Forschung Politik - Strategie – Manag.* 3, 24–27.

Krempkow, R. (2017). Das Wissenschaftssystem vom Kopf auf die Füße stellen? Ein Kommentar [Turning the scientific system form head to toe? a commentary]. *Zeitschrift Qual. Wissenschaft* 3, 116–117.

Krempkow, R., Huber, N., and Winkelhage, J. (2014). Warum verlassen Promovierte die Wissenschaft oder bleiben? Ein überblick zum (gewünschten) beruflichen Verbleib nach der Promotion [Why do doctoral graduates leave science or stay? An overview of the (desired) professional stay after the doctorate]. *Qual. Wissenschaft* 4, 96–106.

Krempkow, R., and Sembritzki, T. (2017). Die Vereinbarkeit von Wissenschaft und Familie in Deutschland: Bestandsaufnahme aus Sicht von Hochschulen und Nachwuchsforschenden [Compatibility of academia and family in Germany. Evaluation from the perspective of universities and junior researchers]. *Beiträge Hochschulforschung* 39, 102–123.

Krempkow, R., Sembritzki, T., Schürmann, R., and Winde, M. (2016). *Personalentwicklung für den wissenschaftlichen Nachwuchs [Personnel development for junior scientists]*. Essen: Stifterverband.

Kwiek, M., and Antonowicz, D. (2015). "The changing paths in academic careers in European universities: minor steps and major milestones," in *Academic Work and Careers in Europe. Trends, Challenges, Perspectives*, eds T. Fumasoli, G. Goastellec, and B. M. Kehm (Berlin: Springer), 41–68. doi: 10.1007/978-3-319-10720-2_3

Kyvik, S. (2013). The academic researcher role: enhancing expectations and improved performance. *Higher Educ.* 65, 525–538. doi: 10.1007/s10734-012-9561-0

Law on fixed-term employment contracts in academia [WissZeitVG] (2016). Wissenschaftszeitvertragsgesetz – WissZeitVG), in der Fassung des Ersten Gesetzes zur Änderung des Wissenschaftszeitvertragsgesetzes vom 11. März 2016 (BGBl. I S. 442. Available online at: https://www.bmbf.de/files/WissZeitVG_idF_WissZeitVGAendG(1).pdf (accessed December 5, 2020).

Lindahl, J., Colliander, C., and Danell, R. (2021). The importance of collaboration and supervisor behaviour for gender differences in doctoral student performance and early career development. *Stud. Higher Educ.* 46, 2808–2831. doi: 10.1080/03075079.2020.1861596

Løvoll, H. S., Røysamb, E., Vittersø, J., and Zourbanos, N. (2017). Experiences matter: positive emotions facilitate intrinsic motivation. *Cogent Psychol.* 4:323. doi: 10.1080/23311908.2017.1340083

McLennan, B., McIlveen, P., and Perera, H. (2021). A pedagogical model of autonomy, competence and relatedness for pre-service teacher educators. *J. Educ. Teach.* 47, 186–200. doi: 10.1080/02607476.2021.1876500

Meuleners, J. S., Neuhaus, B. J., and Eberle, J. (under revision): The role of scholarly identity and basic needs support during doctoral studies on career aspirations of early career scientists. *Stud. High. Educ.*

Meyer, L., Seidel, R., and Prenzel, R. (2006). Wenn Lernsituationen zu Leistungssituationen werden: Untersuchung zur Gehlerkultur in einer Videostudie [When learning situations become performance situations: Research on the culture of error in a video study]. *Schweizerische Zeitschrift Bildungswissenschaften* 28, 21–41.

Neuhaus, B. J., and Braun, E. (2007). "Testkonstruktion und Testanalyse: Praktische Tipps für empirisch arbeitende Didaktiker und Schulpraktiker [Test construction and test analysis: practical advices for empirically working educational scientists and school practitioners]," in *Forschungen zur Fachdidaktik: Vol. 9. Kompetenzentwicklung und Assessment*, ed. H. Bayrhuber (Innsbruck: Studienverlag), 135–164.

Olafsen, A. H., Deci, E. L., and Halvari, H. (2018). Basic psychological needs and work motivation: a longitudinal test of directionality. *Motivat. Emot.* 42, 178–189. doi: 10.1007/s11031-017-9646-2

Peixoto, F., Mata, L., Monteiro, V., and Sanches, C. (2016). How do you feel about math?" relationships between competence and value appraisals, achievement emotions and academic achievement. *Eur. J. Psychol. Educ.* 32, 385–405. doi: 10.1007/s10212-016-0299-4

Pek, J., Wong, O., and Wong, A. C. M. (2018). How to adress non-normality: a taxonomy of approaches, reviewed, and illustrated. *Front. Psychol.* 9:2104. doi: 10.3389/fpsyg.2018.02104

Pekrun, R. (2006). The control-value theory of achievement emotions: assumptions, corollaries, and implications for educational research and practice. *Educ. Psychol. Rev.* 18, 315–341. doi: 10.1007/s10648-006-9029-9

Pekrun, R. (2019). "Achievement emotions: a control-value theory perspective," in *Emotions in Late Modernity, Routledge Studies in the Sociology of Emotions*, eds R. Patulny, A. Belocchi, R. E. Olson, S. Khorana, J. McKenzie, and M. Peterie (New York, NY: Routledge), 142–157.

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., and Perry, R. P. (2011). Measuring emotions in students' learning performance: the achievement emotions questionnaire (AEQ). *Contemporary Educ. Psychol.* 36, 36–48.

Pekrun, R., Goetz, T., and Perry, R. P. (2005). *Achievement Emotions Questionnaire (AEQ): User's Manual.* Munich: Department of Psychology, University of Munich.

Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., and Goetz, T. (2017). Achievement emotions and academic performance: longitudinal models of reciprocal effects. *Child Dev.* 88, 1653–1670. doi: 10.1111/cdev.12704

Pekrun, R., Murayama, K., Marsh, H. W., Goetz, T., and Frenzel, A. C. (2019). Happy fish in little ponds: testing a reference group model of achievement and emotion. *J. Pers. Soc. Psychol.* 117, 166–185. doi: 10.1037/pspp0000230

Pekrun, R., and Stephens, E. J. (2010). "Achievement emotions in higher education," in *Higher Education: Handbook of Theory and Research*, 25th Edn, ed. J. C. Smart (Dordrecht: Springer), 257–306.

Rasch, B., Friese, M., Hofmann, W., and Neumann, E. (2006). *Quantitative Methoden: Einführung in die Statistik [Quantitative Methods: Introduction in Statistics], 2. erweiterte Aufl.).* Heidelberg: Springer Medizin Verlag.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., and Ryan, R. M. (2000). Daily well-being: the role of autonomy, competence, and relatedness. *Personal. Soc. Psychol. Bull.* 26, 419–435.

Restubog, S. L. D., Ocampo, A. C. G., and Wang, L. (2020). Taking control amidst the chaos: emotion regulation during the COVID-19 pandemic. *J. Vocational Behav.* 119:103440. doi: 10.1016/j.jvb.2020.103440

Roth, G., Vansteenkiste, M., and Ryan, R. M. (2019). Integrative emotion regulation: process and development from a self-determination theory perspective. *Dev. Psychopathol.* 31, 945–956. doi: 10.1017/S0954579419000403

Saavedra, R., and Kwun, S. K. (2000). Affective states in job characteristics theory. *J. Organ. Behav.* 21, 131–146.

Sarabipour, S., Schwessinger, B., Mumoki, F. N., Mwakilili, A. D., Khan, A., Debat, H. J., et al. (2020). Evaluating features of scientific conferences: a call for improvements. *Nat. Hum. Behav.* 5, 296–300. doi: 10.1038/s41562-021-01067-y

Schüttelkopf, E. M., and Vogl, U. (2015). "Betriebliches Lernen aus Fehlern: Praxisorientierte Überlegungen zur systematischen Weiterentwicklung der Fehlerkultur in Industrieunternehmen [Learning from errors in organizations: practical considerations for the systematic further development of the error culture in industrial companies]," in *Funktionen von Fehlern im Kontext individueller und gesellschaftlicher Entwicklung*, eds M. Gartmeier, H. Gruber, T. Hascher, and H. Heid (Münster: Waxmann), 245–257.

Shao, K., Pekrun, R., Marsh, H. W., and Loderer, K. (2020). Control-value appraisals, achievement emotions, and foreign language performance: a latent interaction analysis. *Learn. Instruct.* 69:101356. doi: 10.1016/j.learninstruc.2020. 101356

Shapiro, S. S., and Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika* 52, 591–611.

Sheldon, K. M., Ryan, R. M., and Reis, H. T. (1996). What makes for a good day? competence and autonomy in the day and in the person. *Personal. Soc. Psychol. Bull.* 22, 1270–1279.

Shields, S. A. (2000). "Thinking about gender, thinking about theory: gender and emotional experience," in *Studies in Emotion and Social Interaction. Gender and Emotion: Social Psychological Perspectives*, ed. A. Fischer (New York, NY: Cambridge University Press; Editions de la Maison des Sciences de l'Homme), 3–23.

Sloan, M. M. (2004). The effects of occupational characteristics on the experience and expression of anger in the workplace. *Work Occupat.* 31, 38–72.

Spychiger, M., Kuster, R., and Oser, F. (2006). Dimensionen von Fehlerkultur in der Schule und deren Messung: Der Schülerfragebogen zur Fehlerkultur im Unterricht für Mittel- und Oberstufe [Dimensions of error culture in school and their measurement: the student questionnaire on error culture in the classroom for middle and high schools]. *Schweizerische Zeitschrift Bildungswissenschaften* 28, 87–110.

Staw, B. M., Sutton, R. I., and Pelled, L. H. (1994). Employee positive emotion and favorable outcomes at the workplace. *Organ. Sci.* 5, 51–71.

Teichler, U., Arimoto, A., and Cummings, W. K. (2013). *The Changing Academic Profession: Major Findings of a Comparative Survey.* Dordrecht: Springer.

Tiedens, L. Z., Ellsworth, P. C., and Mesquita, B. (2000). Sentimental stereotypes: emotional expectations for high- and low-status group members. *Personal. Soc. Psychol. Bull.* 26, 560–575.

Tracy, J. L., and Randles, D. (2011). Four models of basic emotions: a review of ekamn and cordaro, izard, levenson, and panksepp and watt. *Emot. Rev.* 3, 397–405.

Tran, A., Kerkstra, R. L., Gardocki, S. L., and Papuga, S. C. (2021). Lessons learned: teaching in-person during the COVID-19 pandemic. *Front. Educ.* 6:690646. doi: 10.3389/feduc.2021.690646

Umucu, E., Chan, F., Lee, B., Brooks, J. M., Reyes, A., Mangadu, T., et al. (2022). Well-Being, PTSD, college adjustment in student veterans. *Front. Educ.* 6:793286. doi: 10.3389/feduc.2021.793286

van der Linden, N., Devos, C., Boudrenghien, G., Frenay, M., Azzi, A., Klein, O., et al. (2018). Gaining insight into doctoral persistence: development and validation of doctorate-related need support and need satisfaction short scales. *Learn. Individual Differ.* 65, 100–111.

van der Rijt, J., Van den Bossche, P., van de Wiel, M. W. J., Segers, M. S. R., and Gijselaers, W. H. (2012). The role of individual and organizational characteristics in feedback seeking behavior in the initial career stage. *Hum. Resource Dev. Int.* 15, 283–301.

Vandercammen, L., Hofmans, J., and Theuns, P. (2014). Relating specific emotions to intrinsic motivation: on the moderating role of positive and negative emotion differentiation. *PLoS One* 9:e115396. doi: 10.1371/journal.pone.011 5396

Vansteenkiste, M., Ryan, R. M., and Soenens, B. (2020). Basic psychological need theory: advancements, critical themes, and future directions. *Motivation Emot.* 23:142. doi: 10.1007/s11031-019-09818-1

Vekkaila, J. (2014). *Doctoral Student Engagement: The Dynamic Interplay between Students and Scholarly communities.* Dissertation, Helsinki: University of Helsinki.

Vicente-Saez, R., and Martinez-Fuentes, C. (2018). Open science now: a systematic literature review for an integrated definition. *J. Bus. Res.* 88, 428–436. doi: 10.1016/j.jebdp.2018.05.001

Watson, M. (2015). When will 'open science' become simply 'science'? *Genome Biol.* 16:101.

Weiss, H. M., and Cropanzano, R. (1996). Affective events theory: a theoretical discussion of the structure, causes and consequences of affective experiences at work. *Res. Organ. Behav.* 18, 1–74.

Wisniewski, B., Zierer, K., and Hattie, J. (2020). The power of feedback revisted: a meta-analysis of educational feedback research. *Front. Psychol.* 10:3087. doi: 10.3389/fpsyg.2019.03087

APPENDIX

Overview about the different scales

Table A1 gives an overview about the seven different scales on variables investigated in this study: Perceived competence and autonomy support, social relatedness to the scientific community, and the research-related achievement emotions enjoyment, anger, frustration, and boredom.

TABLE A1 Overview about the seven different scales of the present study.

Scale	Number of items	Cronbach's α	Example item	Theoretical basis
1. Perceived competence support	4	0.85	I'm always given the impression that I am making progress.	Deci and Ryan, 2000, 2002, 2012
2. Perceived autonomy support	8	0.86	I can always divide up my tasks on my own.	
3. Social relatedness to the scientific community	6	0.92	I feel like a member of my scientific community.	
4. Enjoyment	3	0.83	I'm working in academia with enthusiasm.	Pekrun, 2006; Pekrun et al., 2005, 2011
5. Anger	3	0.76	I'm angry while doing scientific work.	
6. Frustration	2	0.61	While researching I'm frustrated.	
7. Boredom	3	0.73	When researching I'm without energy.	