



Predictive validity of state versus trait challenge and boredom for career aspirations

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ABSTRACT

This study focused on students' perceived challenge, its direct links to career aspirations along with indirect links to career aspirations via boredom. We extended previous findings by differentiating state and trait assessments of challenge and boredom and by investigating within- and between-person relations. We hypothesized overchallenge to go along with reduced career aspirations. Furthermore, boredom should occur due to both over- and underchallenge and should reduce those aspirations. We expected stronger effects of trait challenge and boredom on career aspirations as compared to the respective state reports. The hypotheses were tested in a sample of $N = 753$ high-school students ($M_{age} = 15.72$) from 43 classes by a questionnaire and an experience-sampling approach. Multilevel analyses showed overchallenge being linked to reduced career aspirations; this direct effect was equally strong for trait and state reports. Furthermore, the indirect effect of trait non-optimal challenge (over- or underchallenge) indicated a decrease in career aspirations via trait boredom.

1. Theoretical background

Every classroom includes students of heterogeneous ability and therefore calls for differentiated tasks. It is already known that non-optimal alignments between person factors and environmental factors adversely impact students' outcomes, for example, their wellbeing, depression, performance, and persistence (e.g., Pekrun, Hall, Goetz, & Perry, 2014; Richards, 1993; Spokane, Meir, & Catalano, 2000). In any instructional setting, student challenge, operationalized as the match between students' abilities and the task at hand is of a particular importance (Krannich et al., 2019). Despite indications that non-optimal alignments of abilities and task demands may have long-term negative effects on students' career aspirations (Le, Robbins, & Westrick, 2014; Niles, 1993), there is limited research examining these links. In fact, most of the previous studies examining student challenge did not explicitly focus on this link, but rather, on a more general concept of the

person-environment fit (for a meta-analysis see Kristof-Brown, Zimmerman, & Johnson, 2005).

Furthermore, existing investigations did not differentiate the direction of non-optimal challenge (with the exception of Krannich et al., 2019). Theoretically, one can construe non-optimal challenge as falling into different extremes on a continuum: being overchallenged when task demands exceed personal capabilities, and being underchallenged when task demands are lower than personal capabilities (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010). Non-optimal challenge in the direction of being overchallenged should be negatively linked to students' career aspirations. More specifically, students interpret overchallenge as the domain being too difficult for their individual abilities and hence, lower their expectations for success and avoid going into the corresponding field (Kolvereid, 1996; Lent, Brown, & Hackett, 1994; Lent, Paixao, Da Silva, & Leitão, 2010).

Beyond expectations for success, students' emotions play a pivotal

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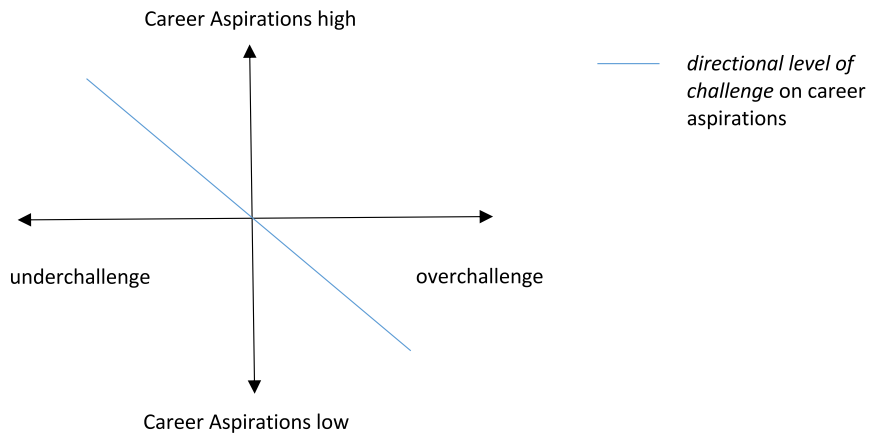


Fig. 2. Graphical depiction of the effect of students' directional level of challenge [UC→OC] on their career aspirations.

dummy-variables assessing overchallenge and underchallenge separately, with the optimal challenge serving as the reference category. Therefore, they were unable to disentangle specific effects of non-optimal challenge on career aspirations as dependent on and independent of the direction of the non-fit.

Other studies examined the person-environment fit and its impact on career choices and job satisfaction without explicitly focusing on non-optimal challenge. For example, [Kristof-Brown et al. \(2005\)](#) conducted a meta-analysis investigating the ability-demand fit in specific occupations and its impact on applicants' job satisfaction. They included studies assessing this fit through various methods, but all of them focused on how well personal (ability) and environmental (job demands) characteristics were matched (for detailed descriptions of the inclusion criteria and operationalizations of aspects of the person-environment fit of single studies see [Kristof-Brown et al., 2005](#)). Overall, the data revealed relatively strong correlations of 0.48 between ability-demands fit and job satisfaction ([Kristof-Brown et al., 2005](#)). Furthermore, a number of older studies investigating Holland's (1973; 1997) person-environment theory of vocational behavior supported the impact of person-environment congruence on vocational satisfaction, stability, and achievement (for meta-analytic results see [Assouline & Meir, 1987](#); [Spokane, 1985](#)). Nevertheless, the vast majority of existing studies neither explicitly focused on students' career aspirations nor differentiated the direction of non-optimal challenge, both of which represent a clear limitation in light of the aforementioned theoretical considerations.

In sum, theoretical considerations support the assumption that students with perceived overchallenge in specific school domains are unlikely to choose occupations related to these domains due to low levels of outcome expectations. There is a gap in the literature exploring the effects of non-optimal challenge dependent upon its direction, i.e. differentiating between students' over- and underchallenge, and in this study we will attempt to provide initial evidence towards closing it.

1.3. Challenge and students' boredom experiences

Students' challenge as ability-difficulty fit impacts their affective experiences. In a school context, over- or underchallenge is a key antecedent of students' boredom ([Daschmann, Goetz, & Stupnisky, 2014](#); [Fisher, 1993](#); [Goetz & Frenzel, 2010](#); [Ringmar, 2017](#)). Boredom is a unique emotional reaction considered to be unpleasant and aversive ([Harris, 2000](#); [Mikulas & Vodanovich, 1993](#); [van Tilburg & Igou, 2012](#)) and characterized by one's perception of time passing slowly ([Vodanovich & Watt, 2016](#)), specific physical expressions ([van Tilburg & Igou, 2012](#)), and disengagement ([Eastwood, Frischen, Fenske, & Smilek, 2012](#)). This inability to engage is considered to be one of the core

features of boredom and it is caused by a mismatch between individuals' needs and the current level of environmental stimulation ([Eastwood et al., 2012](#); [Mugon, Danckert, & Eastwood, 2019](#); [Westgate & Wilson, 2018](#)). In line with this, many theories of boredom use the person-environment-fit framework and show that boredom is highly sensitive to the non-fit (e.g., [Csikszentmihalyi & Csikszentmihalyi, 1975/2000](#); [Westgate & Wilson, 2018](#)). According to the control-value theory (CVT; [Pekrun et al., 2010](#)), boredom in achievement settings arises when students perceive tasks to be underchallenging due to task demands being below students' perceived ability (very high control) or, conversely, when students are overchallenged due to task demands being above individuals' perceived ability level (very low control; [Acee et al., 2010](#); [Daschmann et al., 2011](#)). Hence, non-optimal challenge in both directions should enhance boredom (see [Fig. 3](#)).

In a workplace context, [Fisher \(1993\)](#) described the relation of over- and underload (or over- and underchallenge) and boredom experiences of employees. Similarly, in an interview study in schools, [Kanevsky and Keighley \(2003\)](#) explored gifted students' boredom experiences related to homework and found that easy, repetitive tasks and the lack of challenge were construed by students as antecedents of their boredom and resulted in their choices to skip homework. [Larson and Richards \(1991\)](#) also found that high ability was positively correlated with boredom experiences in a sample of fifth to eighth graders in the U.S., suggesting underchallenge as an antecedent of student boredom experiences, and [van Tilburg and Igou \(2012\)](#) found a positive link between boredom and perceived underchallenge across three different studies.

In addition to these results, several studies revealed that overchallenge also lead to increased boredom experiences. [Acee et al. \(2010\)](#) investigated students' academic boredom in either over- or underchallenging situations detecting a general boredom factor in underchallenging situations in addition to a self-focused (for example characterized by frustration) and a task-focused (for example

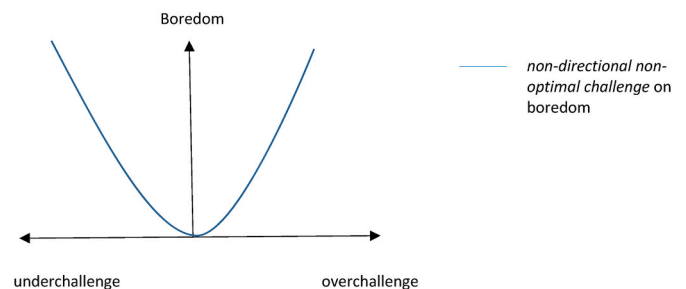


Fig. 3. Graphical depiction of the effect of students' non-directional non-optimal challenge [UC|←→|OC] on boredom.

characterized by a perceived tediousness of the task) boredom factor in overchallenging situations. Furthermore, Daschmann et al. (2011) administered the precursors to boredom scale to 1380 German students ($M_{\text{age}} = 12.56$ years) and showed that both extremes of challenge served as antecedents of boredom in the investigated sample. Asseburg and Frey (2013) directly investigated the objective ability-difficulty fit of mathematics tasks in a sample of $N = 9425$ German ninth-graders and observed a negative linear relation between the fit and students' boredom experiences. Finally, correlational and even experimental evidence from Westgate and Wilson (2018) revealed 1) a curvilinear relationship of psychology students' perceived difficulty (i.e., over- and underchallenge) with boredom and showed that 2) overstimulation (and not just understimulation as in the studies of van Tilburg and Igou, 2012) lead to an increase in boredom.

1.4. Boredom and students' career aspirations

Boredom in school settings is experienced as an unpleasant emotional state (e.g., Goetz et al., 2019; van Tilburg & Igou, 2012). When students are unable to engage in satisfying activities and when they attribute this disengagement to their environment (Eastwood et al., 2012), those who experience boredom frequently are unlikely to select a career related to the boredom-inducing school subject. Surprisingly, whereas numerous studies investigated students' boredom experiences and their negative effects on various outcomes, such as academic achievement and motivational variables (e.g., Tze, Daniels, & Klassen, 2016), only one study examined links between boredom and students' career aspirations in a sample of $N = 662$ Swiss 11th grade high-school students in the domains of German, French, and mathematics (Krannich et al., 2019). The results revealed negative relations for all domains. Research into decision making supports the assumption that boredom as an unpleasant emotion negatively impacts individuals' career choices. That is, decision-making processes and the formation of future aspirations are guided by one's past momentary affective experiences (e.g., Fredrickson, 2000; Peters, Västfjäll, Gärling, & Slovic, 2006). More specifically, frequent boredom experiences in specific school subjects may be negatively connected to students' career aspirations (i.e., to their desire to work in related occupations later due to emotion-related memories and cognitions; Baumeister, Vohs, Nathan DeWall, & Zhang, 2007; Rusting, 1998).

Overall, it seems plausible that *directional non-optimal challenge*, especially overchallenge, could be directly connected to students' career aspirations based on the expected probability of success or failure in the future occupations. Furthermore, students' perceived non-optimal challenge should not only impact their behavior directly, but indirectly influence their aspirations via boredom.

1.5. Trait versus state challenge and boredom and its connection to students' career aspirations

1.5.1. Inter-versus intraindividual relations between challenge and boredom

Students' challenge and their boredom experiences in specific school domains could be either conceptualized as a general tendency of a person to feel challenged or bored in specific domains (*trait* concept; e.g., Nett et al., 2017; Pekrun et al., 2011) or as a situational state of feeling challenged or bored in specific situations (*state* concept; e.g., Ahmed, van der Werf, Minnaert, & Kuyper, 2010; Nett, Goetz, & Hall, 2011). Thus, students' *state* challenge and *state* boredom depend on the momentary situation, whereas their *trait* challenge and *trait* boredom reflect evaluations of being over- or underchallenged or being bored over extended period of time. Assessing challenge and boredom not as trait construct exclusively is rather meaningful as both constructs can be assumed to clearly vary across specific situations.

Situational *state* assessments that repeatedly gauge students' momentary challenge and their boredom experiences in class enable the investigation of the relation of these constructs within- and between-person, hence, on an intraindividual as well as an interindividual level

(Hamaker, Nesselroade, & Molenaar, 2007; Murayama et al., 2017). Conversely, trait assessments of challenge or boredom focus on between-person relations of those variables; hence, they only allow for interindividual analyses (Murayama et al., 2017). Pekrun's control-value theory as well as some other, more general theories explaining boredom through the person-environment non-fit tend to focus on intraindividual dynamics (Csikszentmihalyi & Csikszentmihalyi, 1975/2000; Pekrun et al., 2010; see also Goetz et al., 2016). These theories suggest that for a specific student, *state* boredom occurs in situations when this student experiences situational *state* of being over- or underchallenged. In other words, variance in over- or underchallenge within a person across situations can lead to variations in experiences of boredom across those situations within this person. However, existing empirical studies take a purely interindividual approach to examine the relation of trait over- and underchallenge with trait boredom. In other words, these studies investigate whether existing variance in over- or underchallenge across persons leads to the variance in boredom across those persons (e.g., Daschmann et al., 2012; Larson & Richards, 1991; van Tilburg & Igou, 2012). It is important to note that interindividual analyses can be highly important with respect to corresponding research questions on the between-person level. As such, it would be misleading to argue in favor of one of the two approaches.

As far as we know, studies examining *state* challenge and *state* boredom on an intraindividual level are still lacking. Consequently, we do not know yet if the relations of being over- and underchallenged with boredom experiences are comparable within and between-person. However, initial theoretical and empirical evidence suggests that there is a positive connection of over-, and underchallenge with boredom both on an intra- as well as interindividual level. This means that on the one hand, students' situational experience of over- or underchallenge should enhance their situational boredom (within-person) and on the other hand, under- and overchallenged students should be more likely to get bored compared to students who are optimally challenged (between-person). Studies in related fields found intra- and interindividual analyses to converge. For example, Goetz et al. (2016) showed similar relations between achievement goals and academic emotions on an inter- and intraindividual level.

1.5.2. Interindividual relations between challenge, boredom, and career aspiration

As compared to challenge and boredom, career aspiration as a future oriented perspective can be assumed to be rather stable across specific situations. Consequently, it only makes sense to assess this construct as a *trait*. Hence, the impact of state challenge and state boredom on trait career aspirations is done from a multi-level perspective on the between-person level (i.e., interindividual analyses) exclusively (i.e., L2 person level, L1 level of single state assessments).

With respect to the impact of challenge and boredom on trait career aspiration, the more stable *trait* challenge and boredom are more predictive of aspirations than the in-situ *state* challenge and boredom. This assumption is based on the accessibility model of emotional self-report by Robinson and Clore (2002a). From the perspective of this model, trait assessments of boredom (and other emotions) can be seen as individuals' general evaluation of boredom which is influenced by their judgment of self. Trait assessments of boredom gauge generalized self-views (i.e., beliefs about oneself) retrieved from individuals' semantic memory networks (Kihlstrom, Beer, & Klein, 2003; Robinson & Clore, 2002a, 2002b; Robinson & Sedikides, 2009) and thus are more predictive of future outcomes (Amelang, Bartussek, Stemmler, & Hagemann, 2006; Bieg, Goetz, & Hubbard, 2013). Students' career aspirations represent a distal outcome and should therefore more strongly depend on students' self-beliefs about their boredom experiences as compared to their actual situational states (Robinson & Sedikides, 2009). With respect to the quality of this relation, higher boredom in specific school subjects should reduce the probability of students' aspirations to pursue a career in a subject, in which these boredom

experiences occurred.

We propose that the mechanism described by the accessibility model of emotional self-report could also be applied to students' challenge. This construct can be assumed to vary across situations. Thus, we will assess challenge as a situational state (*state* assessment) in a specific task or a specific momentary situation – in addition to more traditional assessments of perceived levels of challenge related to a specific school domain (*trait* assessment). Similarly to students' boredom, students' career aspirations should be more strongly related to students' *trait* as compared to their *state* challenge.

2. The present study

In the current study we conceptualized students' perceived challenge in two different ways. On the one hand, we defined challenge as (1) students' *non-directional non-optimal challenge* (i.e., being over- or underchallenged) and (2) on the other hand as students' *directional non-optimal challenge* on the continuum ranging from one's extreme underchallenge to extreme overchallenge (and including an optimal level of challenge). Furthermore, we examined the impact of both operationalizations on students' career aspirations and boredom experiences. Based on theoretical considerations from the person-environment fit, social cognitive, and appraisal theories as well as considering existing empirical results, we hypothesized that (H1) a higher level of directional non-optimal challenge would be negatively linked to students' career aspirations due to their interpretation of the domain as being too difficult. We do not have an explicit assumption about links between students' non-directional non-optimal challenge and their career aspirations. (H2a) We hypothesized that a higher level of non-directional non-optimal challenge, on the other hand, would function as an antecedent of students' boredom experiences, so that higher levels of either over- or underchallenge would be positively related to students' boredom on both intraindividual and interindividual levels. When considering correlations between students' directional level of non-optimal challenge and boredom, we hypothesized no significant correlation when looking at intra- as well as interindividual relations. (H2b) We also expected boredom to be negatively related to students' mathematics-related career aspirations, and (H3) we hypothesized an indirect effect of non-directional non-optimal challenge on students' career aspirations via boredom, which should not hold true in case of the directional non-optimal challenge. Additionally, we hypothesized (H4) that the expected relation of directional non-optimal challenge with career aspirations and the connection of boredom with these aspirations (Hypothesis 1 and 2b) as well as the proposed indirect effect (Hypothesis 3) should be stronger in case of trait assessments as compared to state assessments of challenge and boredom (for a graphical depiction of the hypotheses see Fig. 4).

3. Methods

3.1. Ethical statement

Data collection, data protection, and ethical issues of the present study were handled according to the guidelines of the German Association for Psychology (*Deutsche Gesellschaft für Psychologie (DGPs) (2016)*) and the *American Psychological Association (2010)*. Student participation was voluntarily, parents signed an informed consent, and data analyses were conducted on anonymized data.

3.2. Sample and procedure

The sample consisted of $N = 753$ German students from 43 classes in 21 schools with a mean age of 15.72 years ($SD = 0.89$). 55.4% of the students of the final sample self-identified as girls. Students were in the ninth and tenth grade of the highest track of the German school system (i.e., Gymnasium; around 40% of the German students attend this school

track; *Federal Statistical Office, 2020*).

Perceived trait challenge, trait boredom, students' career aspirations, and demographic data were assessed in mathematics classes using a standardized questionnaire. This questionnaire was presented to the students at the end of the third trimester of the school year. Students' state challenge and state boredom were assessed via a personal diary, designed as a short questionnaire to be filled out by each student after each mathematics lesson for the duration of three consecutive weeks. Only students with at least three diary entries were included in the final analyses, which resulted in $N = 4374$ state assessments with an average of 6.02 ($SD = 2.49$; range: 3–14) diary entries per student.

3.3. Study measures

3.3.1. Perceived trait and state challenge

To measure perceived trait as well as state challenge in mathematics, single items were used. These were constructed and tested in a qualitative as well as a quantitative study (*Haag & Götz, 2012; Schnell, 2009*). Previous research suggested that single items are sufficient for measuring subjective experiences that are generally unambiguous (see *Ainley & Patrick, 2006; Gogol et al., 2014; Nagy, 2002; Robins, Hendin, & Trzesniewski, 2001*). The trait challenge item gauged students' perceived general difficulty level in mathematics (*Mathematics classes are usually ... for me.*) on a 5-point Likert scale, ranging from 1 (*too easy*) to 5 (*too difficult*) with a middle category of 3 (*optimal*). The item wording of the state item was constructed parallel to the trait item, but focusing on the specific situational mathematics lesson (*Today's mathematics lesson was ... for me.*). As such, students answering the question with 1 or 2 (*too easy, a little bit too easy*) were labeled as "being underchallenged", whereas students answering the question with 4 or 5 (*a little bit too difficult, too difficult*) were labeled as "being overchallenged".

3.3.2. Trait and state boredom

For the assessment of trait boredom two items were used. These items were developed for a study that examined learning and achievement in mathematics (PALMA; *Götz, 2004; Pekrun, Goetz, & Frenzel, 2005*; "In my mathematics classes, I generally feel bored." and "I usually experience boredom in mathematics classes."). For the state assessment two parallel items ("In today's mathematics lesson, I felt bored." and "In today's mathematics lesson, I experienced boredom.") were administered. A five-point Likert scale was used for both boredom types ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

3.3.3. Students' career aspirations

To measure students' career aspirations in mathematics, items were constructed based on items from the TIMSS 2011 (*Mullis, Martin, Foy, & Arora, 2012*) and PISA 2006 (*OECD, 2009*) studies. The final scale consisted of four items (e.g., "I can imagine having a job that requires a lot of math skills.") reported on a Likert scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*) with a Cronbach's alpha of .93.

3.4. Data analyses

All analyses were conducted with Mplus 7.11 (*Muthén & Muthén, 1998–2017*). Structural equation modeling procedures were used to test direct and indirect effects of students' challenge on career aspirations. The model parameters were estimated by the MLR estimator, which is a maximum likelihood estimator robust to non-normality and non-independence of observations (*Yuan & Bentler, 2000*) and in the case of the measurement models of the latent constructs, we applied an effect-coding procedure to circumvent a stronger impact of the first item (*Little, Rhemtulla, Gibson, & Schoemann, 2013; Little, Slegers, & Card, 2006*). Model fit was determined by using the Comparative Fit Index (CFI; *Bentler, 1990*), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). In case of CFI and TLI, values greater than 0.95 or 0.90 were classified as excellent or acceptable fit of

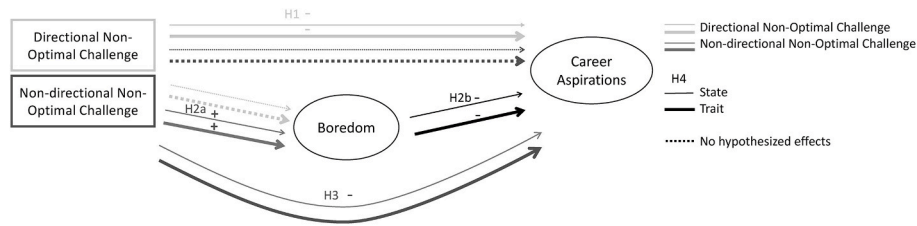


Fig. 4. Graphical depiction of the proposed hypotheses.

the data (Hu & Bentler, 1999), and RMSEA values lower than 0.06 or 0.08 were considered as additional indicators of good or acceptable model fit.

3.4.1. Multilevel modeling approach and operationalization of students’ challenge

Multilevel structural equation modeling was used to test our hypotheses including trait and state measures of challenge and boredom as well as the measure of students’ career aspirations. The tested model included linear as well as quadratic effects of the variable measuring students’ challenge. This procedure enabled us to investigate effects of *directional non-optimal challenge* (linear effect ranging from underchallenge via optimal challenge to overchallenge) and *non-directional non-optimal challenge* (curvilinear, quadratic effect ranging from optimal challenge to strong non-fit – either over- or underchallenge) on students’ boredom experiences and their career aspirations. This is especially important as we expect a higher level of boredom in the case of students’ non-directional non-optimal challenge (being over- or being underchallenged), but lower career aspirations only in the case of a higher level of overchallenge (hence, positive relations of the directional non-optimal challenge and students’ career aspirations). As such, we recoded Likert-scaled variables measuring trait and state challenge. Hence, the original variables ranging from 1 (labeled as being underchallenged) to 5 (labeled as being overchallenged) were recoded into -2, -1 (labeled as being underchallenged), 0 (labeled as optimally challenged), and 1, 2 (labeled as being overchallenged; *directional non-optimal challenge*). These recoded variables were included into the model together with the same variables with exponentiated values resulting in a coding scheme of 0 (labeled as perfectly challenged), 1 (labeled as slight non-fit), 4 (labeled as strong non-fit; quadratic effect: *non-directional non-optimal challenge*; for a graphical depiction see Fig. 5). All resulting recoded variables (linear trait challenge, quadratic trait challenge, linear state challenge, quadratic trait challenge) were directly included into the model as manifest variables.

3.4.2. Hierarchical data structure

Our dataset had a nested data structure with measurement points ($M = 6.31, SD = 2.35$) nested within students ($N = 753$) within classes ($N = 43$). We used the “type is complex” option of *Mplus* to correctly estimate standard errors considering that students were nested within classes and then implemented a two-level general multilevel mediation modeling approach suggested by Preacher, Zyphur, and Zhang (2010) accounting for the special data structure (within- and between measures of challenge and boredom, predicting between-measures of career aspirations²). As such, the effects of both types of state challenge (linear and quadratic) on state boredom were modeled on the within- and between-levels. On the other hand, the direct paths of state as well as

trait challenge (linear and quadratic) and state and trait boredom on students’ career aspirations were modeled on the between-level, together with the indirect effects. This was due to the assessment of students’ career aspirations only as a trait, hence, as the between-level construct, which enables us to compare state (between) effects with trait (between) effects of challenge and boredom on students’ career aspirations. Since we wanted to compare the relations of both trait and state data with the outcome variable, we tested the hypothesized intercorrelations in one model including the trait as well as state data. We z-standardized all variables beforehand, and used the “model indirect” option to calculate standardized indirect effects for the trait variables (Muthén & Muthén, 1998–2017). Furthermore, we calculated additional coefficients by multiplying the regression coefficients of challenge on boredom and boredom on career aspirations of the state data to obtain indirect effects of the state variables (see also Appendix A1 for the model syntax of the final multilevel structural equation model).

4. Results

4.1. Preliminary analyses

Analyses of frequencies of students’ perceived over- and underchallenge as a situational state revealed that 15.1% of students felt underchallenged, 22.6% were overchallenged, and 60.2% reported an optimal level of challenge. For trait challenge, 14.5% of the students reported being underchallenged, 50% being overchallenged, and 32.1% reported an optimal level of challenge (see also Figure A2 of the Appendix). Descriptive statistics revealed a manifest mean score of 2.32 ($SD = 1.10$) for state boredom and 2.59 ($SD = 0.99$) for trait boredom with a missing rate of 1.1% and 6.7%, respectively. On average, students experienced a medium level of boredom in mathematics. Intra-class correlations of the two state boredom items were $ICC = 0.400$ and $ICC = 0.386$, respectively. Cronbach’s alpha for the state boredom scale was $\alpha = 0.88$ across all measurement points and $\alpha = 0.85$ for trait boredom. The manifest mean score for the students’ math-related career aspirations was 2.31 ($SD = 1.20$) with a missing rate of 8.6%. Cronbach’s alpha for the career aspirations scale was $\alpha = 0.94$. Manifest inter-correlations of the study variables on the between- and within-level are presented in Table 1.

4.2. Multilevel model

Our final multilevel model showed acceptable fit with CFI = 0.97, TLI = 0.95, and RMSEA = 0.03 (Hu & Bentler, 1999); 32.4% of variance in students’ career aspirations was explained in the respective model. For an overview of coefficients see Table 2 and Figures A3 and A4 of the Appendix).

Consistent with hypothesis 1, we found negative direct effects of *directional non-optimal challenge* in mathematics classes on students’ math-related career aspirations for both state and trait assessments of challenge ($\beta_{lin_State} = -.34, p < .001$; $\beta_{lin_Trait} = -.32, p < .001$). Furthermore, there was no significant effect of *non-directional non-optimal challenge* on career aspirations for the state assessment ($\beta_{quad_State} = -.09, p = .256$). Surprisingly, our data shows a positive effect of non-directional non-optimal challenge on career aspirations for

² With the measurement model being defined as $Y_{ij} = \Lambda \eta_{ij}$, the within structural model being defined as $\eta_{ij} = \alpha_j + B_j \eta_{ij} + \xi_{ij}$, and the between structural model being defined as $\eta_j = \mu + \beta \eta_j + \xi_j$ with $\xi_{ij} \sim MVN(0, \Psi)$ and $\xi_j \sim MVN(0, \psi)$ (see also Preacher et al., 2010 and Appendix B of Preacher et al., 2010 for the detailed equations of the 1-1-2 multilevel structural equation model).

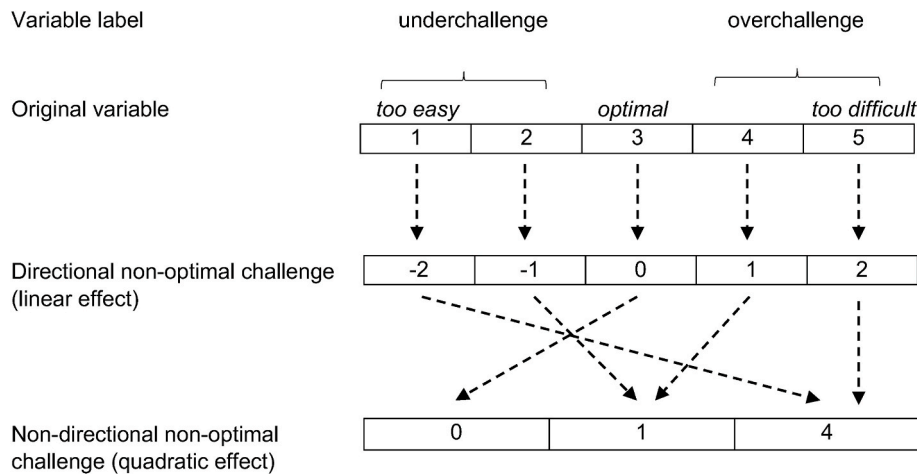


Fig. 5. Operationalization of students' challenge as directional non-optimal challenge [UC→OC] and non-directional non-optimal challenge [UC|← →|OC].

Table 1

Manifest correlations between challenge, boredom, and career aspiration of the state and trait assessment.

		1	2	3	4	5	6	7	8	9	10	11	12
1	Chall _{State_linear}	–	-.254	.016	-.024	.610	.081	.056	-.014	-.396	-.423	-.349	-.387
2	Chall _{State_quadratic}	.068	–	.288	.312	-.110	.393	.141	.188	.081	.066	.060	.067
3	BO1 _{State}	.007	.196	–	.964	.111	.206	.508	.503	-.084	-.063	-.076	-.079
4	BO2 _{State}	.013	.187	.667	–	.090	.197	.497	.512	-.079	-.039	-.069	-.075
5	Chall _{Trait_linear}	–	–	–	–	–	.273	.202	.133	-.474	-.462	-.448	-.428
6	Chall _{Trait_quadratic}	–	–	–	–	–	–	.353	.352	-.096	-.103	-.051	-.076
7	BO1 _{Trait}	–	–	–	–	–	–	–	.740	-.221	-.183	-.159	-.204
8	BO2 _{Trait}	–	–	–	–	–	–	–	–	-.158	-.141	-.161	-.141
9	CA1 _{Trait}	–	–	–	–	–	–	–	–	–	.827	.777	.876
10	CA2 _{Trait}	–	–	–	–	–	–	–	–	–	–	.704	.811
11	CA3 _{Trait}	–	–	–	–	–	–	–	–	–	–	–	.763
12	CA4 _{Trait}	–	–	–	–	–	–	–	–	–	–	–	–

Note. Chall = Chall_{State_linear} = State directional non-optimal challenge; Chall_{State_quadratic} = State non-directional non-optimal challenge; Chall_{Trait_linear} = Trait directional non-optimal challenge; Chall_{State_quadratic} = Trait non-directional non-optimal challenge; BO_{State} = Academic state boredom; BO_{Trait} = Academic trait boredom; CA = Career Aspirations; Correlations above the diagonal are between person correlations (level 2, person); correlations below the diagonal are within person correlations (level 1, situation); N_{Level 1} = 4.372 (assessments within students), N_{Level 2} = 753 (students).

trait assessment ($\beta_{quad_Trait} = 0.10, p < .01$).

In line with hypothesis 2a, there were no linear effects of students' directional non-optimal challenge on boredom for either state (both, within- and between-person) or trait assessments ($\beta_{lin_State_Within} = -.01, p = .833$; $\beta_{lin_State_Between} = 0.10, p = .208$; $\beta_{lin_Trait} = 0.08, p = .056$). When it comes to the quadratic effects, a higher non-directional non-optimal challenge (being over- or underchallenged) significantly related to the higher state and trait boredom for both state and trait challenge assessments ($\beta_{quad_State_Within} = 0.17, p < .001$; $\beta_{quad_State_Between} = 0.40, p < .001$; $\beta_{quad_Trait} = 0.33, p < .001$). Overall and in line with our expectations, higher non-optimal challenge (independently from the direction of non-fit) was associated with higher boredom for both assessment methods as well as on the within and the between level. In other words, students' non-directional non-optimal challenge enhanced their experienced boredom on an interindividual level (between students) as well as on an intraindividual level (within students).

Examining the effects of boredom in mathematics on students' math-related career aspirations, we found no significant (between) effect of state boredom on students' career aspirations ($\beta_{State} = 0.08, p = .266$), but trait boredom was significantly negatively linked to their career aspirations ($\beta_{Trait} = -.22, p < .001$) supporting hypothesis 2b.

When it comes to the proposed indirect effect of students' non-directional non-optimal challenge in mathematics on students' math-related career aspirations via state boredom, it was insignificant for state assessments ($\beta_{quad_State_Between_ind} = 0.03, p = .252$). This was also true for indirect effects of students' directional non-optimal challenge on

career aspirations via state boredom ($\beta_{lin_State_Between_ind} = 0.01, p = .435$). The results were different for trait assessments. In line with hypothesis 3, we showed a significant negative indirect effect for students' non-directional non-optimal challenge ($\beta_{quad_Trait_ind} = -.07, p < .001$). Again, there was no significant indirect effect for directional non-optimal challenge ($\beta_{lin_Trait_ind} = -.02, p = .067$). Thus, only a higher level of non-optimal trait challenge was indirectly and negatively linked to students' career aspirations via trait boredom.

With respect to the differentiation of state and trait assessment of challenge and boredom (Hypothesis 4), there was no indirect effect of the quadratic state challenge variable (state non-directional non-optimal challenge) on students' career aspirations via state boredom (as already described in the section above; $\beta_{quad_State_Between_ind} = 0.03, p = .252$), but a significant indirect effect of the quadratic trait challenge variable (trait non-directional non-optimal challenge) on career aspirations via trait boredom ($\beta_{quad_Trait_ind} = -.07, p < .001$). Furthermore, the regression coefficient of state boredom on students' career aspirations was not significant ($\beta_{State} = 0.08, p = .266$), whereas for trait boredom it was significant ($\beta_{Trait} = -.22, p < .001$). This is consistent with our hypothesis that trait emotions (i.e., boredom) are more important for career aspirations than situational, state boredom experiences. This pattern was not found with respect to state and trait challenge: The effect of state directional non-optimal challenge on career aspirations ($\beta_{lin_State} = -.34, p < .001$) was similar in size to the effect of trait directional non-optimal challenge on career aspirations ($\beta_{lin_Trait} = -.32, p < .01$). Hence, our results supported the hypothesis of the greater impact of trait compared to state reports on career aspirations

Table 2
Total, direct, and indirect within and between effects of the general two-level model.

Directional Non-Optimal Challenge			<i>B</i>	<i>SE</i>
Within				
Direct BO _{State} on Chall _{State_linear}			-.01	(.03)
Between				
Direct BO _{State} on Chall _{State_linear}			.10	(.08)
Direct BO _{Trait} on Chall _{Trait_linear}			-.08	(.04)
Direct CA on Chall _{State_linear}			-.34***	(.07)
Direct CA on Chall _{Trait_linear}			-.32***	(.05)
Indirect CA on Chall _{State_linear} via BO _{State}			.01	(.01)
Indirect CA on Chall _{Trait_linear} via BO _{Trait}			-.02	(.01)
Total CA on Chall_{Trait_linear}			-.34***	(.05)
Non-directional Non-Optimal Challenge				
Within				
Direct BO _{State} on Chall _{State_quadratic}			.17***	(.02)
Between				
Direct BO _{State} on Chall _{State_quadratic}			.40	(.09)
Direct BO _{Trait} on Chall _{Trait_quadratic}			.33***	(.04)
Direct CA on Chall _{State_quadratic}			-.09	(.08)
Direct CA on Chall _{Trait_quadratic}			.10**	(.04)
Indirect CA on Chall _{State_quadratic} via BO _{State}			.03	(.03)
Indirect CA on Chall _{Trait_quadratic} via BO _{Trait}			-.07***	(.02)
Total CA on Chall_{Trait_quadratic}			.03	(.03)
Boredom				
Between				
CA on BO _{State}			.08	(.08)
CA on BO _{Trait}			-.22***	(.05)

Note. Chall_{State_linear} = State directional non-optimal challenge; Chall_{State_quadratic} = State non-directional non-optimal challenge; Chall_{Trait_linear} = Trait directional non-optimal challenge; Chall_{State_quadratic} = Trait non-directional non-optimal challenge; BO_{State} = Academic state boredom; BO_{Trait} = Academic trait boredom; CA = Mathematical Career Aspiration. Sample size was *N* = 619. All regression coefficients are standardized; standard errors are displayed in brackets.

p* < .01; *p* < .001.

in the case of students' boredom, but not for students' challenge (for an overview of the total, direct, and indirect within and between effects of the two-level model see Table 2).

5. Discussion

This study examined students' perceived challenge in the domain of mathematics and its effect on students' boredom in mathematics and their math-related career aspirations. We investigated these relations with the help of a differentiated operationalization of students' challenge, combined with trait and state assessments of challenge and students' boredom. By including state measures for the variables of challenge and boredom we were able to investigate both interindividual and intraindividual relations. It is important to note that beyond the relation between challenge and boredom, all analyses were run on the between-person level (i.e., interindividual analyses).

The focus on students' perceived challenge and its effects on boredom and students' career aspirations is important to understand, given the general striving toward achieving optimal alignments of the classroom environment to students' individual needs. The results of our study supported the key role of students' perceived challenge in predicting their career aspirations. Further, the study showed to the prominent role of boredom arising from non-optimal challenge for career aspirations and demonstrated higher predictive power of trait as compared to state boredom (Schuster, Bieg, & Hubbard, 2016; Wirtz et al., 2003). We thereby took into consideration students' non-optimal challenge which could be either operationalized as a linear construct

(directional non-optimal challenge) ranging from the one extreme (underchallenge) to the other (overchallenge) as well as a quadratic construct conceptualizing non-optimal challenge independently from the direction of non-fit (non-directional non-optimal challenge). Whereas students' non-directional non-optimal challenge was related to higher boredom experiences in both state and trait assessments, the effect of boredom on students' career aspirations was only significant and negative in case of the trait boredom.

More specifically, our study showed that directional state and trait non-optimal challenge was a negative predictor of students' career aspirations. Hence, both an increased level of situational (i.e. state) overchallenge over a series of mathematics lessons as well as students' more general perceptions of overchallenge (i.e. trait) in the domain of mathematics were linked to reduced career aspirations. We assessed the construct of challenge as a self-evaluation of the fit between the students' perceived abilities and the imposed demands of the mathematics lesson (Malmberg & Little, 2007; Nicholls, 1984). Hence, it is logical that those students' who evaluated their level of overchallenge in mathematics as relatively high did not want to go into mathematics-related domains as they presumably cognitively appraised their abilities in those fields as insufficient (e.g., Lent et al., 1994).

Furthermore, the situational as well as habitual directional non-optimal challenge was not significantly related to students' boredom experiences, but the level of non-directional non-optimal challenge was. Therefore, our results, combined with experimental evidence from van Tilburg and Igou (2012) and Westgate and Wilson (2018) showed that a mismatch between environmental demands and students' abilities in both directions (i.e., over- or underchallenge) lead to boredom. In our study students with a higher level of non-directional non-optimal challenge reported higher levels of boredom. This holds true for the situational non-directional non-optimal challenge which was related to higher situational boredom on the within-person as well as on the between-person level. Also, a more stable, habitual non-directional non-optimal challenge enhanced in all three cases habitual mathematics-related boredom experiences.

These findings are consistent with research that viewed non-optimal challenge as an antecedent of both situational state boredom (e.g., Csikszentmihalyi & Csikszentmihalyi, 1975/2000; Fahlman, Mercer-Lynn, Flora, & Eastwood, 2013) or of a more stable trait boredom (e.g., Acee et al., 2010; Daschmann et al., 2011; Goetz & Frenzel, 2010; Titz, 2001). These results expand previous studies by explicitly testing intraindividual relations of these constructs. Hence, when an individual student appraises a mathematics-related situation as either over- or underchallenging, this non-optimal challenge correlates with higher situational boredom for the student, which is in line with the concept of person-environment fit and Pekrun's control-value theory (Csikszentmihalyi & Csikszentmihalyi, 1975/2000; Pekrun, 2006; Pekrun et al., 2010). Additionally, we found this relation to be similar across persons, that is, when looking at interindividual relations. Accordingly, when looking at individuals' state challenge and state boredom in the subject of mathematics, our study showed stable relations on both within- and between-person levels. This is not a trivial result against the background of within-person processes being frequently different from results of between-person analyses (Molenaar, 2004; Molenaar & Campbell, 2009). Furthermore, we demonstrated that higher habitual boredom was negatively linked to students' career aspirations in mathematics. The effects of boredom on these aspirations remained significant even after controlling for the direct effect of students' perceived challenge on career aspirations. As such, the results of this study support prior findings that showed that boredom as a negative habitual emotion could influence students' career aspirations (Krannich et al., 2019).

Our study did not reveal any structural differences between the trait and state assessments, but the results of our study supported the assumption that trait boredom had a stronger relation to students' future career choices than situational state boredom. This result is consistent

with earlier studies indicating higher predictive power of trait assessments for future behavior and choices compared to state assessments (e.g., Levine et al., 2009; Wirtz et al., 2003). Although trait assessments do not capture students' actual momentary emotional experiences and situational fluctuations and do not account for intra-individual variability (e.g., Bieg, Goetz, & Lipnevich, 2014; Schwarz, 2012), these assessments are of key importance for students' career aspirations and, presumably, other outcomes that are based on individuals' expectations and beliefs about themselves (e.g., Amelang et al., 2006; Robinson & Sedikides, 2009). Interestingly, we did not find a greater role of trait assessments compared to state assessments for challenge in predicting math-related career aspirations. However, this result might be explained by considering situational state challenge as a cognitive variable that might be more stable than situational state boredom. That is, semantic memories and situation-specific beliefs about students' own abilities may have come into play while the students rated their perceived situational challenge (Robinson & Clore, 2001; 2002a). On the contrary, for situational state assessment of emotional states (i.e., boredom) students may have been directly accessing their situational boredom experiences via current and experiential information and episodic memory (Robinson & Clore, 2002b).

A surprising result of our study was the slightly positive effect of *non-directional non-optimal challenge* on students' career aspirations for trait assessments, which means that a higher general ability-difficulty non-fit in the domain of mathematics could enhance students' aspirations in related domains. This goes contrary to theoretical considerations offered by the person-environment fit theory (e.g., Edwards & Shipp, 2007; Holland, 1997; Spokane et al., 2000). However, this effect has to be interpreted cautiously as it only reflects the quadratic effect of challenge on students' career aspirations and more importantly, careful examination of this trajectory reveals the impact of this effect to be quite weak (see also Figure A5 of the Appendix). Therefore, it is safe to conclude that a higher level of overchallenge was linked to a decrease in students' career aspirations (or, conversely, a higher level of underchallenge was related to an increase in students' career aspirations). The additional slight increase in career aspirations, when being strongly overchallenged should not be over-interpreted. It needs further investigation before attempting to establish the practical meaning of this effect.

5.1. Limitations of the study and future directions

Important limitations of this study are the cross-sectional nature of the data when it comes to the trait assessment and the restricted focus on the domain of mathematics. Theoretically, it seems reasonable to presume that students' career aspirations would be impacted by their level of challenge and their academic boredom (e.g., Le et al., 2014; Peters et al., 2006; Schuster & Martiny, 2017). Nevertheless, the inclusion of longitudinal data to corroborate correlational patterns of trait challenge and boredom with students' career aspirations is needed to corroborate the proposed relations. The focus on mathematics allows us to draw conclusions related to this field as a key STEM-domain (English, 2016; Milaturrehman, Mardiyana, & Pramudya, 2017): The more overchallenged the students' were in mathematics classes, the less they wanted to go into related fields. Based on theoretical considerations and previous studies showing links between challenge and boredom as well as between emotions and career aspirations in other school domains and at the university level (Acee et al., 2010; Daschmann et al., 2011; Krannich et al., 2019; Schuster et al., 2016), we suggest that the investigated relations can be generalized to other school domains, but empirical evidence is needed. Furthermore, the question remains if students' perceived and self-evaluated overchallenge is at least similar to their "true" overchallenge as assessed by competence tests. As this result pattern occurred in case of the state and the trait assessment of students' level of challenge, it seems reasonable that the correlation is based on realistic evaluations of the students' level of ability representing their "true" challenge (e.g., Goetz et al., 2013), although the

state assessment still was a self-reported measure. Investigating students' level of challenge with tests constructed via IRT-based scaling methods (e.g., Embretson & Reise, 2000) in addition to self-reports would be a fruitful avenue of research. This way, studies will be able to compare the impact of students' challenge (perceived trait and state measure as well as an objective measure) on students' academic boredom experiences. Finally, in addition to the assessment of challenge, future studies into career aspiration may assess academic self-concept and/or measures of perceived competence. Although both measures may play a crucial role in the individual judgement of challenge, its role with respect to predicting emotions and career aspirations (see Guo, Parker, Marsh, & Morin, 2015) above and beyond perceived challenge as operationalized in our study might be investigated in future studies.

5.2. Practical implications

Our study demonstrated that students' non-optimal challenge is frequently experienced at school. In addition to the strong relevance of this variable for students' situational boredom on an intra- as well as interindividual level together with its relevance for students' habitual boredom (e.g., Goetz et al., 2019), we showed the negative influence of overchallenge on students' career aspirations. This negative effect of overchallenge also occurred in the case of a situational state challenge. This is a highly relevant finding when it comes to how students choose their future occupation (e.g., Schoon & Parsons, 2002; Trice & McClellan, 1993) as it suggests that students' generally experienced challenge in specific school domains as well as students' situational challenge have long-term impact on career decisions.

Students' boredom was negatively linked to students' career aspirations. This negative emotion should be prevented or reduced, for instance, by teaching students to reappraise the boring situation as valuable. This technique has been proven to be an effective cognitive approach strategy for the reduction of boredom (Daniels, Tze, & Goetz, 2015; Nett, Goetz, & Hall, 2011). In addition, fostering students' individual needs and avoiding non-optimal fit between students' abilities and task demands, particularly in the direction of overchallenge, seems to be a difficult, but a vital responsibility of teachers and educational practitioners (Rogalla & Vogt, 2008).

There are three ways that help to avoid high levels of over-, and underchallenge. First, teachers should be provided with professional development on how to develop excellent diagnostic competencies to recognize the needs of students (Ohle & McElvany, 2015) and consequently adapt their instruction and learning tasks to avoid over- or underchallenge. Second, teachers should support students' active involvement in the classroom by fostering a positive and open learning environment, where students have to actively think about the lesson and are encouraged to ask questions (Reeve, 2002). Third, on a more structural level, using self-regulated learning approaches and consistently integrate e-learning or blended learning elements into the classroom would be helpful (e.g., Cavanaugh, Sessums, & Drexler, 2015; Vaughan, 2014) as they allow to optimally support each student individually based on his or her needs and thereby avoid negative effects on their career aspirations via academic boredom.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.learninstruc.2022.101596>.

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