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RESEARCH ARTICLE



Facing the dropout crisis among PhD candidates: the role of supervisor support in emotional well-being and intended doctoral persistence among men and women

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ABSTRACT

The number of PhD candidates who experience psychological problems has risen significantly over the past few years. Poor mental health can have numerous negative consequences for PhD candidates and their supervisors, as it may adversely affect their quality of life, attrition, and academic productivity. Despite these well-documented challenges, few studies have looked at how the supervisor – supervisee relationship can influence the emotional well-being of male and female doctoral candidates. The current work examined the role of the supervisor's support in emotions and intended doctoral persistence among men ($n = 411$) and women ($n = 514$), in all disciplines at two large universities in Belgium. Results indicate that emotional well-being was low for all doctoral candidates but women experienced even more negative emotions (anxiety, stress, discouragement, demoralization, sadness and depression) and fewer positive emotions (confidence, optimism, happiness, fulfillment, satisfaction and content) than men. Interestingly, we also found that perceived structure and autonomy, two dimensions of supervisor support, have a positive effect on emotional well-being and intention of pursuing a PhD trajectory for both men and women. This paper makes a contribution to the higher education and research supervision literature by offering new directions for research and by providing guidelines for the training of research supervisors.

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Although PhD candidates are recruited from among the brightest and most successful students, the rate of completion of doctoral studies, which is estimated at 40–50% in Western countries (e.g. Golde 2005; Wollast et al. 2018), is the lowest compared to all other degrees (Ampaw and Jaeger 2011). Doctoral attrition is often associated with the higher prevalence of psychological distress among doctoral candidates (Levecque et al. 2017). Many PhD candidates report being overworked and over-stressed (e.g. constant demand for results, time pressure, uncertainty about doctoral processes, sense of belonging in scholarly communities and financial pressures; Cornwall et al. 2018), which negatively affects their mental health (for a review, see Schmidt and Hansson 2018). Levecque and colleagues (2017) found that 51% of Flemish doctoral candidates had experienced at least two symptoms of poor mental health over the course of completing their research degree, 40%

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experienced three symptoms and 32% reported at least four symptoms. Furthermore, their results indicated that these symptoms were more prevalent among doctoral candidates than among highly educated employees and other higher education students. In the same vein, Evans et al. (2018) raised concerns about a mental health crisis in graduate education and showed that the risk of doctoral candidates experiencing such mental health challenges (e.g. depression, anxiety) is up to six times greater than for the general population.

According to the World Health Organization (2004), mental health is a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community. Considering that emotion regulation is an essential feature of mental health (Gross and John 2003), dysregulated emotions are often used as indicators of low psychological well-being (Houben, Van Den Noortgate, and Kuppens 2015). Based on this, a growing body of research has examined the mental health of doctoral candidates through the lenses of the emotional dimension (Cotterall 2013), emotional competencies (O'Meara, Knudsen, and Jones 2013), emotional exhaustion (Devine and Hunter 2017), and self-reported emotions (Evans et al. 2018; Van Der Heijde, Douwes, and Vonk 2019). In this context, Evans et al. (2018) highlighted a critical need for studies that investigate intervention strategies that could address the mental health crisis among PhD candidates. Thus, the present work investigates how PhD candidates' mental health and ultimately their intended doctoral persistence are determined by the dynamics around the supervisor – supervisee relationship. If some facets of doctoral supervision can influence the emotions of male and female candidates, interventions aimed at training supervisors could be an avenue for improving PhD candidates' emotional well-being.

Role of supervisor in terms of self-determination theory

Besides the candidates themselves (De Clercq et al. 2019), the doctoral supervisor is recognized as one of the most important and crucial protagonists in the doctoral journey; for this reason, a large body of research has focused on the supervisor – supervisee relationship (e.g. Andriopoulou and Prowse 2020; Grant, Hackney, and Edgar 2014; Gruzdev, Terentev, and Dzhafarova 2020; Jairam and Kahl 2012). Many studies have found an association between different types of support from the supervisor and PhD candidates' research productivity, career commitment, self-efficacy (Paglis, Green, and Bauer 2006), research progress (Martinsuo and Turkulainen 2011), and satisfaction (Zhao, Golde, and McCormick 2007).

As argued by Devos et al. (2015), a supervisor's support can be analyzed in light of the three basic human needs identified in self-determination theory (SDT; Ryan and Deci 2017). According to Deci and Ryan (2000, 2002), feeling of competence, autonomy, and relatedness, are essential for ongoing psychological growth and integrity, as well as for constructive social development and personal well-being. Relatedness or affiliation, refers to individuals' feelings of connection and closeness with others, having a sense of belongingness (see also Van den Broeck et al. 2010; Van der Linden et al. 2018). Competence refers to individuals' feelings of efficiency and experience of mastery. Third, the need for autonomy refers to individuals' feelings of volition (i.e. the power or ability to decide something by yourself), and experience of integration and freedom (cf. individual agency; McAlpine and Mitra 2015).

According to Deci and Ryan (2002), the satisfaction of these needs can be supported (or thwarted) by the social context. The influence of the social context can manifest itself through three complementary dimensions: involvement versus rejection or neglect, structure versus chaos, and autonomy support versus control or coercion (Olivier et al. 2021; Stroet, Opdenakker, and Minnaert 2013). In this paper, we aim to analyze these dimensions in the context of the supervisor – supervisee relationship (see Devos et al. 2015; Dupont et al. 2014; Van der Linden et al. 2018).

The need for relatedness can be supported within a social environment that cultivates positive interpersonal relationships (Dupont et al. 2014). This can include a focus on empathy and the offer of comfort when the person experiences distress (Ryan and Deci 2017). This implies being

involved in the person's experiences, both positive and negative, which in the context of doctoral candidates' supervision can translate into reassuring students when needed, and showing respect and concern for the student not only as a researcher, but also as an individual. The need for competence is supported within a structured academic context providing clear expectations about the desirable goals to achieve and close guidance throughout the process (Hospel and Galand 2016). For instance, supervisors can prescribe sequential patterns of activity to facilitate candidates' learning process and the achievement of desired outcomes. Furthermore, structured supervisors are attentive to maintaining candidates' motivation and effort by providing both leadership (in terms of communicating clear directions) and support (e.g. constructive feedback), which will help candidates improve their skills and achieve a sense of competence (Jang, Reeve, and Deci 2010).

Finally, an autonomy-supportive style nourishes candidates' volition by providing them with opportunities to make choices and take initiatives. Supervisors who promote candidates' autonomy take into account their perspectives and emotional experiences (Hospel and Galand 2016). That is, they are open to listen to candidates' input, and acknowledge their entitlement to express negative emotions. On the opposite end of the spectrum, controlling supervisors prioritize their own perspective, going as far as demanding that candidates behave and think in a certain way. A supervisor may thus provide a solid structure while simultaneously adopting an autonomy-supportive style (Olivier et al. 2021).

To sum up, in this study, we analyze how the supervisor's support, in terms of involvement, structure, and autonomy, relates to PhD candidates' emotional well-being and intentions to persist in doctoral studies. Moreover, to increase our contribution to the effort of finding efficient solutions for the mental health crisis in the graduate trainee population, we adopt a gender-focused analysis. Indeed, efficient strategies to tackle this problem must first take into account the fact that male and female students do not encounter the same challenges. Additionally, it is possible that the same challenge may be perceived and handled differently among men and women.

A gender-focused analysis of the mental health crisis among PhD candidates

The issue of considerable dropout rate and poor mental health in doctoral programs has been the focus of extensive research highlighting psychological predictors, but also sociodemographic factors such as age, nationality, funding, and gender (Bair and Haworth 2004; Spronken-Smith, Cameron, and Quigg 2018; Wollast et al. 2018). Specifically, regarding gender, some studies have shown that men are more likely to complete their PhD program than women (Groenvynck, Vandeveld, and Van Rossem 2013; Visser, Luwel, and Moed 2007). However, other studies did not find significant gender differences (e.g. Mastekaasa 2005; Van der Haert et al. 2013; Wollast et al. 2018).

Is gender associated with PhD candidates' mental health? Although research is relatively scarce (for a review, see Schmidt and Hansson 2018), a few studies have documented that women experience higher levels of emotional distress than men (e.g. Appel and Dahlgren 2003; Fisher et al. 2019). This pattern is not surprising, given the prevalence of gender inequalities in higher education, particularly in highly selective and prestigious academic contexts, in which women often suffer psychological distress to a greater extent than men (Nerdrum, Rustøen, and Rønnestad 2006; Verger et al. 2009). For instance, during their first year of medical school, women appear significantly more likely than men to have symptoms of depression and anxiety (Hardeman et al. 2015). Moreover, women may also experience higher uncertainty about belonging (e.g. impostor syndrome), higher anxiety, and lower self-efficacy in academic contexts than men (Aelenei et al. 2020; Bian et al. 2018; Harackiewicz et al. 2014; Harackiewicz et al. 2016; Sommet, Pulfrey, and Butera 2013). The reasons for this discrepancy are manifold. One major factor relates to social identity threat, with women fearing that they may be devalued because of their gender, particularly in STEM fields (Murphy, Steele, and Gross 2007; for a review, see Cheryan et al. 2017). Recent research has documented that these deleterious gender-identity dynamics extend to other fields (including humanities and social sciences), in which the belief that success requires brilliance predominates (Leslie

et al. 2015; Meyer, Cimpian, and Leslie 2015). Explicitly linking success to brilliance (instead of dedication and effort, for instance) has a negative effect on female students, because, despite being as brilliant as men, they experience the burden of the stereotype associating brilliance more with men than with women (Bian et al. 2018).

Overview of the present work and hypotheses

Building on the theoretical framework developed by Devos et al. (2015) structuring PhD candidates' supervisory experiences through the three basic needs framework from SDT, and on the gender-focused research in academia (Bian et al. 2018; Cheryan et al. 2017), we aim to investigate the effects of a supervisor's support on emotional well-being (i.e. experience of positive and negative emotions) and intentions to persist in doctoral studies among men and women. Based on the literature discussed here, we formulate the following hypotheses:

Hypothesis 1. We expected men to report lower negative emotions (Hypothesis 1a), but greater positive emotions (Hypothesis 1b) and doctoral persistence (Hypothesis 1c) than women.

Hypothesis 2. To explore the role of the types of supervisor support in intended doctoral persistence, we examined a model including positive and negative emotions as mediators of this relation. We hypothesized that greater perception of structure is negatively linked with negative emotions (Hypothesis 2a) and positively associated with positive emotions (Hypothesis 2b) and doctoral persistence (Hypothesis 2c) for both men and women.

Hypothesis 3. We hypothesized that greater perception of autonomy is negatively associated with negative emotions (Hypothesis 3a) and positively associated with positive emotions (Hypothesis 3b) and doctoral persistence (Hypothesis 3c) for both men and women.

Hypothesis 4. We hypothesized that greater perception of involvement is negatively linked with negative emotions (Hypothesis 4a) and positively associated with positive emotions (Hypothesis 4b) and doctoral persistence (Hypothesis 4c) for both men and women.

Hypothesis 5. We postulated that doctoral persistence is positively associated with positive emotions (Hypothesis 5a) and negatively associated with negative emotions (Hypothesis 5b) among men and women.

Hypothesis 6. We expected indirect effects of the types of support on intended doctoral persistence through positive and negative emotions (Hypothesis 6). Ultimately, we do not have a priori hypotheses on the relative magnitude of indirect effects of involvement, structure and autonomy between men and women.

Method

Participants

We recruited PhD candidates in all disciplines at the two largest universities in the French-speaking community of Belgium, [Anonymized for review]. The questionnaire was sent by email to 3,230 PhD candidates registered in the two universities and was completed by 925 of them (for more information about our national doctoral context, see Wollast et al. 2018).¹ In total, 925 PhD candidates participated in this study. Of these, 411 were male and 514 were female. The participants completed an online questionnaire voluntarily and without compensation. Table 1 reports the distribution of men and women as a function of socio-demographic factors. In sum, men and women shared the same socio-demographic characteristics except for the field of research, with men outnumbering women in sciences and technologies, whereas the reverse occurred in social sciences and humanities.

Measures

The questionnaire was administered in French. All of the items in French and their English translations are available in the online supplementary material (<https://osf.io/y2znx>).

Table 1. Distribution of men ($n = 411$) and women ($n = 514$) as a function of socio-demographic factors.

	Men	Women		Men	Women
<i>Nationality</i>			<i>Age</i>		
Belgian nationals	70%	73%	Younger than 26 years old	55%	58%
Nationals from another EU country	16%	18%	Between 26 and 40 years old	40%	38%
Non-EU nationals	14%	9%	Older than 40 years old	5%	4%
<i>Number of children</i>					
None	81%	77%	2 children	6%	7%
0 but I am or my partner is pregnant	2%	2%	3 children	2%	2%
1 child	7%	11%	4 children or more	2%	1%
<i>Final evaluation in master's degree program</i>			<i>Marital status</i>		
Highest distinction	20%	24%	Single	42%	34%
High distinction	44%	51%	Engaged in a committed relationship	32%	34%
Distinction	31%	22%	Married	26%	31%
Satisfaction	5%	3%	Widowed	0%	1%
<i>Position</i>			<i>Research field</i>		
Non-university funding or research project (grant or contract)	62%	64%	Sciences and technologies	44%	24%
Assistant lectureship	25%	23%	Health sciences	19%	24%
Two types of funding (e.g. grant and assistant)	2%	3%	Social sciences	28%	34%
No funding or unknown funding	11%	10%	Human sciences	8%	18%

Doctorate-related Need Support Scale. Participants indicated on a Likert scale ranging from 1 (*Totally disagree*) to 5 (*Totally agree*) the extent to which they agreed with each of the 12 items of the validated Need Support Scale (Van der Linden et al. 2018). Specifically, we used the three dimensions of this scale (four items per dimension), namely involvement (e.g. 'My supervisor reassures me when I need it'), structure (e.g. 'My supervisor gives me good advice on how I should plan and carry out my research') and autonomy (e.g. 'My supervisor encourages me to work in an independent way').

To test whether the three dimensions were psychometrically distinct from each other, we performed confirmatory factor analyses (CFA) and compared several concurrent models (see Table 2). Model fit was assessed using multiple fit indices (Tanaka 1993). The root mean square error of approximation (RMSEA) should be $\leq .08$, and the comparative fit index (CFI) should be $\geq .90$ (Byrne 2004). Additionally, we used the Akaike information criterion (AIC) and Bayesian information criteria (BIC), with indices closer to zero indicating better model fit (Lin, Huang, and Weng 2017). The CFA model was based on maximum likelihood estimation. CFAs indicated that the model distinguishing the three dimensions demonstrated better model fit statistics. Importantly, all standardized factor loadings were significant and above the conventional threshold ($>.40$). The internal consistency was good for involvement ($\omega_{\text{total}} = .85$; $\omega_{\text{men}} = .84$; $\omega_{\text{women}} = .85$) and structure (ω_{total}

Table 2. Comparisons of concurrent models.

	Model	χ^2	df	CFI	RMSEA	AIC	BIC	Factor loadings
Men	3 factors (IN vs AU vs ST)	134.25	51	.953	.063	188.25	296.76	.44 – .80
	2 factors (IN vs AU and ST)	336.05	53	.839	.114	386.05	486.51	.25 – .78
	2 factors (IN and AU vs ST)	240.45	53	.893	.093	290.45	390.91	.26 – .80
	2 factors (IN and ST vs AU)	363.71	53	.823	.120	413.71	514.18	.42 – .79
	1 factor (IN and AU and ST)	492.85	54	.750	.141	540.85	637.29	.19 – .79
Women	3 factors (IN vs AU vs ST)	154.62	51	.960	.063	208.62	323.16	.48 – .84
	2 factors (IN vs AU and ST)	415.35	53	.859	.115	465.35	571.40	.18 – .83
	2 factors (IN and AU vs ST)	308.35	53	.900	.097	358.35	464.41	.28 – .83
	2 factors (IN and ST vs AU)	401.78	53	.864	.113	451.78	557.84	.48 – .78
	1 factor (IN and AU and ST)	567.75	54	.800	.136	615.75	717.57	.24 – .79
Men	2 factors (Pos vs Neg)	75.55	26	.968	.068	113.55	189.90	.56 – .88
	1 factor (Pos and Neg)	269.21	27	.843	.148	305.21	377.55	.52 – .82
Women	2 factors (Pos vs Neg)	68.86	26	.978	.057	106.86	187.46	.51 – .84
	1 factor (Pos and Neg)	228.94	27	.899	.121	264.94	341.30	.47 – .79

Note: IN = Involvement; AU = Autonomy; ST = Structure; Pos = Positive emotions; Neg = Negative emotions.

= .85; $\omega_{\text{men}} = .84$; $\omega_{\text{women}} = .86$) and suboptimal for autonomy ($\omega_{\text{total}} = .62$; $\omega_{\text{men}} = .61$; $\omega_{\text{women}} = .63$), as in the original study (Van der Linden et al. 2018).

Emotional engagement. This scale assessed the emotions that participants experienced while they were working on their PhD (Baudoin and Galand 2017; Dupont et al. 2014). Participants were asked to rate statements about nine emotions on a scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Four items assessed positive emotions (e.g. 'I feel confident/optimistic when I work on my PhD') and five items assessed negative emotions (e.g. 'I feel anxious/stressed when I work on my PhD').

To test whether positive emotions and negative emotions were psychometrically distinct from each other, we performed CFA and compared two concurrent models (one factor versus two factors, see Table 2). CFAs indicated that the model distinguishing positive emotions and negative emotions demonstrated better model fit statistics than when we combined them together. Importantly, all standardized factor loadings were significant and above the conventional threshold ($>.40$). The internal consistency was good for positive ($\omega_{\text{total}} = .85$; $\omega_{\text{men}} = .84$; $\omega_{\text{women}} = .85$) and negative ($\omega_{\text{total}} = .81$; $\omega_{\text{men}} = .81$; $\omega_{\text{women}} = .81$) emotions.

Intended doctoral persistence. Participants were required to respond to six items (e.g. 'I am seriously considering quitting my PhD'; reversed) assessing intended doctoral persistence (Neuvillle et al. 2007; Van der Linden et al. 2018) on a scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Internal consistency was good ($\omega_{\text{total}} = .80$; $\omega_{\text{men}} = .78$; $\omega_{\text{women}} = .81$).

Multi-group measurement invariance

Prior to comparing participants' responses to the survey, it was necessary to demonstrate that male and female participants interpreted the questions on our measures in a similar manner (Vandenberg and Lance 2000). To do so, we estimated different levels of measurement invariance on the full structural model using AMOS (Byrne 2004). The model fit was assessed using the cut-off criteria of $CFI > .90$ and $RMSEA < .08$ (Hu & Bentler, 1999). First, an unconstrained (i.e. configural) model verifies that the general factor structure of the measure is the same across different groups by freely estimating parameters in each of the groups (i.e. the same model without any invariance in both groups, but parameters may vary). This unconstrained model constitutes a basis for comparison to test for invariance. Second, a constrained metric model is run in which measurement weights of the latent variables are constrained to be equal. Third, an additional constrained scalar model is run in which the loadings and intercepts are constrained to be equal. Finally, a strict invariance model is tested in which factor loadings, intercepts and residuals are constrained to be equal across groups (Putnick and Bornstein 2016). However, strict invariance is not a prerequisite for testing mean group differences (Vandenberg and Lance 2000). To determine whether measurement invariance was present, we tested metric invariance by comparing the metric model with constrained measurement weights to the unconstrained configural model, then tested scalar invariance by comparing the scalar model with constrained intercepts to the metric model with constrained measurement weights, and finally we tested strict invariance by comparing the scalar model with the residual model (Byrne 2004). Changes in $CFI < .01$ and in $RMSEA < .015$ are considered indicators of invariance (Chen 2007).

We first tested measurement invariance using the unconstrained full structural model, which revealed good model fit ($\chi^2 = 1419.740$, $df = 618$, $CFI = .924$, $RMSEA = .037$). Second, we compared this configural model with a constrained model ($\chi^2 = 1446.851$, $df = 639$, $CFI = .924$, $RMSEA = .037$), which confirmed that full metric invariance was achieved ($\Delta CFI = 0$, $\Delta RMSEA = 0$). Third, we created an additional constrained scalar model with constrained intercepts and loadings ($\chi^2 = 1539.433$, $df = 666$, $CFI = .918$, $RMSEA = .038$) and compared it with the metric model with constrained measurement weights ($\Delta CFI = .006$, $\Delta RMSEA = .001$), thus confirming that full scalar invariance was reached. Finally, we compared this scalar model with the residual (i.e. strict) model, where factor loadings, intercepts and residual variances were constrained to be

equal ($\chi^2 = 1580.276$, $df = 693$, $CFI = .916$, $RMSEA = .037$) and found that strict invariance was achieved ($\Delta CFI = .002$, $\Delta RMSEA = .001$).

Results

Correlations and latent mean differences

Table 3 reports the correlations, means and standard deviations of all variables for men and women, and also testing differences between means. As expected, all correlations were significant ($p < .001$) and in the expected direction. Independent-samples t -tests were conducted to compare the different variables for men and women respondents. Following the recommendations on statistical practice made by Delacre, Lakens, and Leys (2017), we relied only on Welch's t -test, instead of a student's t -test, when comparing our two independent groups. Furthermore, Bonferroni corrections for multiple testing were introduced. Specifically, we compared each of the p -values to the alpha threshold divided by the number of dependent variables. In sum, significance was reached when $p < .05/6 = .008$. Given the large sample size in this study, the risk of type 1 error was relatively limited. This significance level allowed us to detect a d of .23 with 80% power. However, to fully inform the reader, in Table 3 we report the 95% CI for the differences between the means for the two groups.

First, there was no main effect of gender on the three dimensions of the Need Support Scale (involvement, structure and autonomy). Second, in line with hypotheses 1a and 1b, we observed a main effect of gender on positive and negative emotions. In fact, women reported significantly stronger negative emotions and weaker positive emotions than men did. Third and in line with hypothesis 1c, we found a main effect of gender on intended doctoral persistence, with men reporting higher persistence than women.

To go further, we looked at each positive and negative emotion individually. Table 4 reports the means and standard deviations of all emotions for men and women. Results indicated that women reported feeling more anxious/stressed (especially), more discouraged/demoralized, less confident/optimistic, less happy/fulfilled and less satisfied/contented, than men (ranked by effect size). Furthermore, women reported feeling more sad/depressed than men, but this difference was marginally significant. Finally, we did not find gender differences for angry/revolted, ridiculous/ashamed and curious/captivated.

Table 3. Correlation matrix with women ($n = 514$) above the diagonal and men ($n = 411$) below the diagonal and means (standard deviations) differences as a function of gender.

	Involvement	Structure	Autonomy	Positive emotions	Negative emotions	Doctoral persistence
Involvement	1	.66**	.42**	.34**	-.35**	.28**
Structure	.56**	1	.23**	.37**	-.36**	.35**
Autonomy	.41**	.17**	1	.28**	-.30**	.26**
Positive emotions	.27**	.42**	.14**	1	-.65**	.58**
Negative emotions	-.24**	-.27**	-.27**	-.60**	1	-.54**
Doctoral persistence	.26**	.39**	.15**	.56**	-.54**	1
Men	3.99 (0.85)	3.61 (0.90)	4.07 (0.69)	3.53 (0.78)	2.25 (0.84)	4.18 (0.74)
Women	3.98 (0.92)	3.57 (0.98)	4.09 (0.73)	3.29 (0.86)	2.43 (0.88)	4.01 (0.84)
Total	3.98 (0.89)	3.59 (0.94)	4.08 (0.71)	3.40 (0.83)	2.35 (0.86)	4.09 (0.80)
Welch's t	0.04	0.65	0.38	4.47	-3.22	3.21
df	902.875	903.165	894.366	906.981	891.209	911.448
p	> .05	> .05	> .05	< .001	= .001	= .002
95% CI	[-.109; .122]	[-.082; .163]	[-.111; .075]	[.136; .348]	[-.294; -.071]	[.065; .269]
Cohen's d	.01	.04	.03	.29	-.21	.21

Note: The scales vary between 1 and 5. ** = Correlation is significant at the 0.008 level. Confidence intervals that do not contain zero are considered significant (Mallinckrodt et al. 2006).

Table 4. Means (standard deviations) differences of all emotions for men ($n = 411$) and women ($n = 514$).

	Anxious Stressed	Angry Revolted	Sad Depressed	Ridiculous Ashamed	Discouraged Demoralized	Confident Optimistic	Curious Captivated	Happy Fulfilled	Satisfied Contented
Men	3.19 (1.24)	1.83 (1.11)	2.16 (1.19)	1.64 (0.94)	2.41 (1.13)	3.47 (0.95)	3.87 (0.90)	3.40 (1.00)	3.40 (0.97)
Women	3.61 (1.19)	1.77 (1.11)	2.33 (1.26)	1.70 (1.05)	2.74 (1.25)	3.09 (1.06)	3.80 (0.95)	3.11 (1.09)	3.17 (1.07)
Total	3.43 (1.23)	1.80 (1.11)	2.25 (1.23)	1.68 (1.00)	2.59 (1.21)	3.26 (1.03)	3.83 (0.93)	3.24 (1.06)	3.27 (1.03)
Welch's <i>t</i>	−5.24	−0.86	−2.14	−0.92	−4.10	5.76	1.14	4.19	3.40
<i>df</i>	860.867	874.664	898.037	910.798	909.001	907.939	893.950	905.074	908.354
<i>p</i>	< .001	> .05	= .033	> .05	< .001	< .001	> .05	< .001	= .001
95% <i>CI</i>	[−.576; −.261]	[−.081; .208]	[−.331; −.014]	[−.191; .070]	[−.474; −.167]	[.250; .513]	[−.051; .190]	[.152; .425]	[.095; .362]
Cohen's <i>d</i>	−.35	−.05	−.14	−.06	−.28	.08	.01	.28	.23

Note: Standard deviations are presented in parentheses. The scale varies between 1 and 5. Confidence intervals that do not contain zero are considered significant (Mallinckrodt et al. 2006).

Multi-group modeling

Before testing our mediation model, we analyzed two more parsimonious models in which we were interested in the direct effects of the types of support on doctoral persistence (Figure 1s and Figure 2s) and emotions (Figure 3s and Figure 4s) separately (see Online Supplementary Material).

Mediation model. The structural equation model provided excellent fit in terms of the *RMSEA* (.037) and adequate fit in terms of the *CFI* (.924). Standardized path coefficients for men and women are shown in Figures 1 and 2, respectively. Additionally, we tested the equality of correlations and standardized regression coefficients between men and women using a series of Wald χ^2 tests (Klopp 2019). Specifically, we assessed constraints on statistical parameters (i.e. correlations and regression paths individually and independently) based on the weighted distance between the unrestricted estimate and its hypothesized value under the null hypothesis, where the weight is the precision of the estimate (Fahrmeir et al. 2013; Ward and Ahlquist 2018).

In line with our hypotheses, the three dimensions of the Need Support Scale were strongly and positively intercorrelated with each other among men and women. Turning now to regressions, in line with our hypotheses (2a, 2b, 2c), the structure dimension was positively associated with positive emotions and intended doctoral persistence and negatively associated with negative emotions among men and women. Second, the autonomy dimension was negatively associated with negative emotions among men and women (Hypothesis 3a). Furthermore, this dimension also positively predicted positive emotions and intended doctoral persistence among women, but not among men (3b, 3c). Third, and contrary to our expectations, the involvement dimension was found to be *negatively* associated with intended doctoral persistence among women (Hypothesis 4c). Remarkably, this path coefficient was not significant for men. Ultimately, Wald χ^2 tests revealed that only two coefficient paths differed significantly (and marginally) between men and women: the paths from autonomy ($\Delta\chi^2 = 4.114$, $p = .043$) and positive emotions ($\Delta\chi^2 = 3.445$, $p = .063$) to intended doctoral persistence were stronger among women than among men. All other path coefficients did not differ significantly between gender groups ($p > .063$) for each (χ^2 difference for all other regressions).

Furthermore, and as expected, positive emotions were positively associated with intended doctoral persistence (Hypothesis 5a), whereas negative emotions were negatively associated with intended doctoral persistence (Hypothesis 5b), for men and women. Importantly, Wald χ^2 tests revealed that the magnitude of the correlations did not differ significantly between men and women ($p > .05$ for each χ^2 difference for all correlations).

To complement our statistical analysis, we explored indirect effects (Hypothesis 6). Table 5 reports the magnitude and significance of indirect effects of the types of support on doctoral persistence by

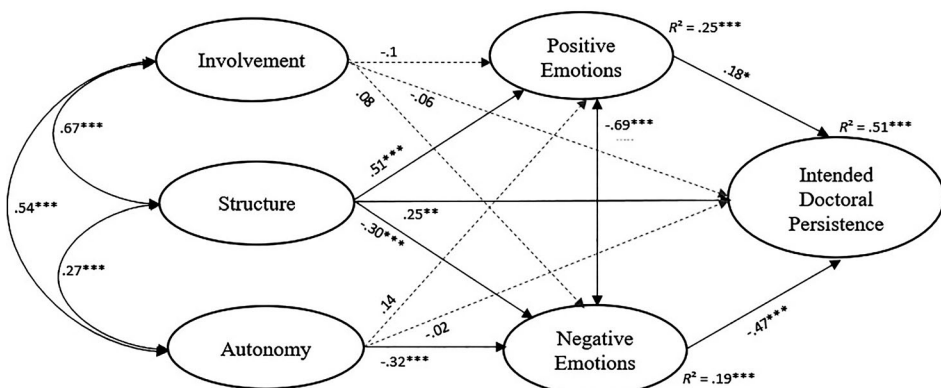


Figure 1. Standardized path coefficients for men ($n = 411$). Solid, black paths are significant whereas grey, dashed pathways are not ($p > .05$). * $p < .05$. ** $p < .01$. *** $p < .001$.

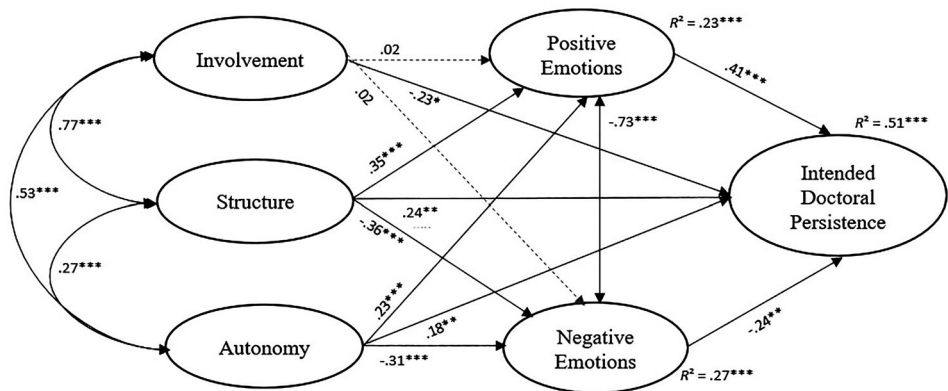


Figure 2. Standardized path coefficients for women ($n = 514$). Solid, black paths are significant whereas grey, dashed pathways are not ($p > .05$). * $p < .05$. ** $p < .01$. *** $p < .001$.

way of positive and negative emotions for men and women. When comparing all indirect effects, findings differed depending on gender. For women, the path through positive emotions explained the effect of structure and autonomy on doctoral persistence most strongly. For men, this was true of the path through negative emotions. Indirect effects through involvement were not significant for either men or women.

Ultimately, the high value of the coefficients of determination (R^2 , see Figures 1 and 2) indicates that an important proportion of the variance in the dependent variables was explained by the independent variables for both men and women. This suggests that the regression models fit the observed data reasonably well.

Discussion

Research examining the mental health of PhD candidates is flourishing; however, little is known about the associations between the supervisor – supervisee relationship and emotional well-being. Rooted in the framework of self-determination theory and adopting a perspective sensitive to the gender differences documented in academia, the current work examined the role of the supervisor’s support as a predictor of emotions and intended doctoral persistence among male and female PhD candidates from all disciplines at the two largest universities of the French-speaking Community of Belgium. In line with a growing body of research (e.g. Evans et al. 2018; Levecque et al.

Table 5. Magnitude and significance of indirect effects of the types of support on doctoral persistence by positive and negative emotions as a function of gender.

Gender	Predictor	Mediator	<i>B</i>	<i>SE</i>	95% <i>CI</i>
Male	Involvement	Positive emotions	–.015	.022	[–.073; .006]
		Negative emotions	–.030	.051	[–.122; .047]
Female	Involvement	Positive emotions	.006	.022	[–.073; .090]
		Negative emotions	–.005	.051	[–.064; .034]
Male	Structure	Positive emotions	.078	.053	[–.002; .172]
		Negative emotions	.116	.047	[.051; .203]
Female	Structure	Positive emotions	.127	.048	[.063; .223]
		Negative emotions	.079	.041	[.027; .165]
Male	Autonomy	Positive emotions	.025	.026	[–.001; .093]
		Negative emotions	.147	.057	[.073; .264]
Female	Autonomy	Positive emotions	.103	.044	[.046; .195]
		Negative emotions	.081	.043	[.029; .179]

Note: Confidence intervals that do not contain zero are considered significant (Mallinckrodt et al. 2006) and are highlighted in bold.

2017), we found that poor levels of emotional well-being are present among doctoral candidates (e.g. anxiety and stress), particularly among female candidates. Indeed, we found that women experience stronger negative emotions (anxiety, stress, discourage, demoralization, sadness and depression) and weaker positive emotions (confidence, optimism, happiness, fulfillment, satisfaction and content) than men do. Moreover, women reported weaker intended doctoral persistence. This is consistent with previous findings documenting that women may have a more challenging academic experience than their male counterparts, particularly in highly selective and prestigious academic settings (Cheryan et al. 2017; Hardeman et al. 2015), such as PhD programs. However, in appraising such effects, it is important to keep in mind that gender inequality often results from the accumulation of small effects that can ultimately tip the balance (cf. Martell, Lane, and Emrich 1996). Similarly, it is well-established that dropout from a PhD program also results from the accumulation of individual risk factors (see Wollast et al. 2018). Ultimately, in light of self-determination theory, our research provides evidence that several dimensions of supervisor support are related to emotional well-being and intended persistence in the PhD trajectory.

The role of the supervisor's support

Building on and extending the findings of Devos et al. (2015) on doctoral supervisors' styles as viewed through self-determination theory, we demonstrated that the supervisor's provision of structure, involvement, and autonomy support is strongly associated with the way candidates feel and anticipate their future. Specifically, we focused on the role of the supervisor's support, not as a cause of gender differences in academia, but as a way to improve the emotional experience for both genders. Indeed, there were no gender differences in the perceived support from the supervisor. Thus, in this context, one cannot argue that women experienced stronger negative emotions because they perceived weaker support.

Importantly, our results indicate that the need-satisfaction dimensions of supervision play a beneficial role in how male and female doctoral candidates feel and perceive their doctoral trajectory. Whereas the three dimensions were positively associated with mental health outcomes for both genders, the dimension of structure was found to be the most important (Hospel and Galand 2016). This suggests that both male and female candidates need a structured academic environment that provides clear expectations and communication, constructive feedback, close guidance, and attention to maintaining the candidate's motivation and effort (Olivier et al. 2021). This is consistent with research showing that perceiving a lack of meaning and low progress are strong predictors of doctoral dropout (De Clercq et al. 2021; Devos et al. 2016). Finally, although both genders benefit from well-articulated supervision, the positive effect of structure could particularly help to mitigate the emotional distress among women in STEM PhD programs, as suggested by a recent study (Fisher et al. 2019). Furthermore, the autonomy dimension was found to be directly associated with positive emotions and intended doctoral persistence only among women. Thus, an autonomy-supportive style as opposed to a controlling one may particularly benefit women. This may be the case because supervisors who promote candidates' autonomy are actively taking into account candidates' perspective and input, which may give female candidates the empowerment and the confidence that would be diminished by different negative stereotypes. In the same vein, as a potential way to mitigate negative effects of identity threat for women in PhD programs, specifically in STEM fields, other research has found that greater autonomy support from the supervisor was associated with higher research self-efficacy (Overall, Deane, and Peterson 2011). Finally, autonomy support for female PhD candidates may have a particularly strong positive effect on their emotional well-being, because that will allow them to pursue more freely community-oriented research goals (e.g. serving the community, connecting with others), which are more important for women than men (Diekman et al. 2011).

Turning now to the perceived involvement of the supervisor, our results showed that this dimension is important when considered independently from the other dimensions (see bivariate

correlations), but becomes secondary when all dimensions are introduced in the same model (Dupont et al. 2014). In other words, candidates' need for relatedness through involvement by the supervisor appeared less crucial when the other dimensions are taken into account. If a doctoral candidate works in a well-articulated academic environment (i.e. structure) with opportunities to make choices and take initiatives (i.e. autonomy), the need for a highly involved supervision style becomes less salient for his or her own emotional well-being and doctoral trajectory. For women specifically, the results showed that after partialing out the effects of structure and autonomy, the perceived supervisor involvement negatively predicted intended doctoral persistence. This may be explained by the fact that the meaning left within the involvement dimension after taking out what this dimension shares with structure and autonomy may be in fact harmful for women, potentially perceived as personally invasive, since this involvement might not happen within the context of the PhD project and might lack autonomy. Further studies analyzing the interactive effects of these dimensions would be helpful to clarify this point.

Limitations and future directions

Although this study expands our understanding of how the role of the supervisor shapes PhD candidates' emotional well-being, this study is not without its limitations. First, we only consider the perception of the doctoral candidate; the supervisor's perspective is not taken into account. Future studies should analyze both perspectives and identify if there is congruence between the support perceived to be given and received, in the sense of a style-fit between the supervisor and supervisee. For instance, studies have shown that a research match, which implies working on a doctoral project closely related to the supervisor's own research, increases satisfaction and intended doctoral persistence (van Rooij, Fokkens-Bruinsma, and Jansen 2021).

Second, we did not include the gender of the supervisor in the analysis, which could have an effect and possibly interact with the gender of the PhD candidate. Exploratory analyses revealed that the supervisor gender did not have a main effect and did not interact with the mentee's gender. However, we did not present these results, as some of the categories (e.g. female supervisor supervising female candidate) did not contain enough participants to reach adequate power. We encourage scholars to consider the gender of the supervisor in further studies with larger sample sizes. For instance, research on related topics found that male PhD candidates in STEM programs were more likely than their female counterparts to receive mentorship and sponsorship (i.e. supervisors using their influence to advance the career of their protégé) from senior male academics (O'Connor et al. 2020). Another limitation is that the design is cross-sectional and that claims about causality cannot be established. Furthermore, there may be a selection bias in the sample: If women in our sample have dropped out more than men, as our results suggests (see also Wollast et al. 2018), the size of the difference observed in our study may underestimate true differences at the start of the PhD.

The present study suggests that supervisor-based training that builds structure, autonomy and involvement may have a positive impact on doctoral candidates' emotional well-being. In this context, both [Anonymized for review] offer PhD training programs that provide courses on university policies, procedures for effective supervision, shared experiences and challenges with peers, psychological support, and resources to find further help and guidance. These programs are designed for supervisors as well as for PhD candidates. Importantly, our results may provide insight in the way in which these interventions and training programs can best be implemented. For women, these interventions may require greater attention to autonomy and structure to overcome poorer mental health and additional gender inequalities in higher education. The results of this study suggest that the doctoral candidate is dependent on the his/her supervisor, who has a significant role in his/her doctoral trajectory. Interventions should therefore target both the supervisor and the supervisee, with a specific emphasis on structure and autonomy. Additionally, these interventions could include self-compassion components (Neff 2003) which have been found to

be associated with less negative emotions (Wollast et al. 2020a; Wollast et al. 2020b; Wollast et al. 2023) and more positive emotions (Wollast et al. 2019).

Conclusion

Researchers have called for evidence of a mental health crisis in graduate education. Poor emotional well-being is the result of pressure that manifests in several ways, including constant demand for results, increasingly marketized publications systems, financial pressures, uncertainty about doctoral processes, sense of belonging in scholarly communities and so on. In this context, social environment is a key factor that supposedly helps both male and female doctoral candidates to better cope with these demands and uncertainties. The current study found that the perceived provision of structure and autonomy support by the supervisor can make a significant difference in how male and female candidates think, feel and perceive their future in such a challenging environment.

Note

1. This study is part of a larger national research project across multiple universities in Belgium that aims at understanding the process of doctoral completion in the light of motivational theories, through qualitative, quantitative and longitudinal designs (for more information about the project, see Van der Linden et al. 2018; Wollast et al. 2018).

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Author Contributions

NVdL, BG, AA, MF and OK contributed to the study conception, design and prepared materials and collected data. RW and JC performed statistical analysis. RW and CA wrote the first draft of the manuscript, and all authors critically commented and revised the manuscript.

Ethical Standards

All studies have been approved of by the appropriate ethics committee at the first author's university and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Statement

This study complies with the APA ethical regulations for research on human subjects and all participants gave informed consent, as approved by the institutional review boards of the principal investigators.

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References

- Aelenei, C., D. Martinot, A. Sicard, and C. Darnon. 2020. "When an Academic Culture Based on Self-Enhancement Values Undermines Female Students' Sense of Belonging, Self-Efficacy, and Academic Choices." *The Journal of Social Psychology* 160 (3): 373–389. doi:10.1080/00224545.2019.1675576.
- Ampaw, F. D., and A. J. Jaeger. 2011. "Understanding the Factors Affecting Degree Completion of Doctoral Women in the Science and Engineering Fields." *New Directions for Institutional Research* 2011 (152): 59–73. doi:10.1002/ir.409.
- Andriopoulou, P., and A. Prowse. 2020. "Towards an Effective Supervisory Relationship in Research Degree Supervision: Insights from Attachment Theory." *Teaching in Higher Education* 25 (5): 648–661. doi:10.1080/13562517.2020.1731449.
- Appel, M. L., and L. G. Dahlgren. 2003. "Swedish Doctoral Students' Experiences on Their Journey Towards a PhD: Obstacles and Opportunities Inside and Outside the Academic Building." *Scandinavian Journal of Educational Research* 47 (1): 89–110. doi:10.1080/00313830308608.
- Bair, C. R., and J. G. Haworth. 2004. "Doctoral Student Attrition and Persistence: A Meta-Synthesis of Research." In *Higher Education: Handbook of Theory and Research*, edited by J. C. Smart, 481–534. Springer.
- Baudoin, N., and B. Galand. 2017. "Effects of Classroom Goal Structures on Student Emotions at School." *International Journal of Educational Research* 86: 13–22. doi:10.1016/j.ijer.2017.08.010.
- Bian, L., S. J. Leslie, M. C. Murphy, and A. Cimpian. 2018. "Messages About Brilliance Undermine Women's Interest in Educational and Professional Opportunities." *Journal of Experimental Social Psychology* 76 (January): 404–420. doi:10.1016/j.jesp.2017.11.006.
- Byrne, B. M. 2004. "Testing for Multigroup Invariance Using AMOS Graphics: A Road Less Traveled." *Structural Equation Modeling: A Multidisciplinary Journal* 11: 272–300. doi:10.1207/s15328007sem1102_8.
- Chen, F. F. 2007. "Sensitivity of Goodness of fit Indexes to Lack of Measurement Invariance." *Structural Equation Modeling: A Multidisciplinary Journal* 14: 464–504. doi:10.1080/10705510701301834.
- Cheryan, S., S. A. Ziegler, A. K. Montoya, and L. Jiang. 2017. "Why are Some STEM Fields More Gender Balanced Than Others?" *Psychological Bulletin* 143 (1): 1–35. doi:10.1037/bul0000052.
- Cornwall, J., E. C. Mayland, J. van der Meer, R. A. Spronken-Smith, C. Tustin, and P. Blyth. 2018. "Stressors in Early-Stage Doctoral Students." *Studies in Continuing Education* 41 (3): 363–380. doi:10.1080/0158037X.2018.1534821.
- Cotterall, S. 2013. "More Than Just a Brain: Emotions and the Doctoral Experience." *Higher Education Research & Development* 32 (2): 174–187. doi:10.1080/07294360.2012.680017.
- Deci, E. L., and R. M. Ryan. 2000. "The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior." *Psychological Inquiry* 11 (4): 227–268. doi:10.1207/S15327965PLI1104_01.
- Deci, E. L., and R. M. Ryan. 2002. "Overview of Self-Determination Theory: An Organismic Dialectical Perspective." In *Handbook of Self-Determination Research*, edited by E. L. Deci, and R. M. Ryan, 3–33. University of Rochester Press.
- De Clercq, M., C. Devos, A. Azzi, M. Frenay, O. Klein, and B. Galand. 2019. "I Need Somebody to Lean on." *Swiss Journal of Psychology* 78: 101–113. doi:10.1024/1421-0185/a000224.
- De Clercq, M., M. Frenay, A. Azzi, O. Klein, and B. Galand. 2021. "All you Need is Self-Determination: Investigation of PhD Students' Motivation Profiles and Their Impact on the Doctoral Completion Process." *International Journal of Doctoral Studies* 16: 189–209. doi:10.28945/4702.
- Delacre, M., D. Lakens, and C. Leys. 2017. "Why Psychologists Should by Default use Welch's t-Test Instead of Student's t-Test." *International Review of Social Psychology* 30: 92. doi:10.5334/irsp.82.

- Devine, K., and K. H. Hunter. 2017. "PhD Student Emotional Exhaustion: The Role of Supportive Supervision and Self-Presentation Behaviours." *Innovations in Education and Teaching International* 54 (4): 335–344. doi:[10.1080/14703297.2016.1174143](https://doi.org/10.1080/14703297.2016.1174143).
- Devos, C., G. Boudrenghien, N. Van der Linden, A. Assaad, M. Frenay, B. Galand, and O. Klein. 2016. "Doctoral Students' Experiences Leading to Completion or Attrition: A Matter of Sense, Progress and Distress." *European Journal of Psychology of Education* 32 (1): 61–77. doi:[10.1007/s10212-016-0290-0](https://doi.org/10.1007/s10212-016-0290-0).
- Devos, C., N. Van der Linden, G. Boudrenghien, A. Assaad, M. Frenay, B. Galand, and O. Klein. 2015. "Doctoral Supervision in the Light of the Three Types of Support Promoted in Self-Determination Theory." *International Journal of Doctoral Studies* 10: 439–464. doi:[10.28945/2308](https://doi.org/10.28945/2308).
- Diekmann, A. B., E. K. Clark, A. M. Johnston, E. R. Brown, and M. Steinberg. 2011. "Malleability in Communal Goals and Beliefs Influences Attraction to STEM Careers: Evidence for a Goal Congruity Perspective." *Journal of Personality and Social Psychology* 101 (5): 902–918. doi:[10.1037/a0025199](https://doi.org/10.1037/a0025199).
- Dupont, S., B. Galand, F. Nils, and V. Hospel. 2014. "Social Context, Self-Perceptions and Student Engagement: A SEM Investigation of the Self-System Model of Motivational Development (SSMMD)." *Electronic Journal of Research in Education Psychology* 12 (1): 5–32. doi:[10.14204/ejrep.32.13081](https://doi.org/10.14204/ejrep.32.13081).
- Evans, T. M., L. Bira, J. B. Gastelum, L. T. Weiss, and N. L. Vanderford. 2018. "Evidence for a Mental Health Crisis in Graduate Education." *Nature Biotechnology* 36 (3): 282–284. <https://doi.org/10.1038/nbt.4089>. doi:[10.1038/nbt.4089](https://doi.org/10.1038/nbt.4089)
- Fahrmeir, L., T. Kneib, S. Lang, and B. Marx. 2013. *Regression. Models, Methods and Applications*. Springer.
- Fisher, A. J., R. Mendoza-Denton, C. Patt, I. Young, A. Eppig, R. L. Garrell, D. C. Rees, T. W. Nelson, and M. A. Richards. 2019. "Structure and Belonging: Pathways to Success for Underrepresented Minority and Women PhD Students in STEM Fields." *PLoS ONE* 14 (1): e0209279–14. doi:[10.1371/journal.pone.0209279](https://doi.org/10.1371/journal.pone.0209279).
- Golde, C. M. 2005. "The Role of the Department and Discipline in Doctoral Student Attrition: Lessons from Four Departments." *The Journal of Higher Education* 76 (6): 669–700. doi:[10.1353/jhe.2005.0039](https://doi.org/10.1353/jhe.2005.0039).
- Grant, K., R. Hackney, and D. Edgar. 2014. "Postgraduate Research Supervision: An 'Agreed' Conceptual View of Good Practice Through Derived Metaphors." *International Journal of Doctoral Studies* 9: 043–060. doi:[10.28945/1952](https://doi.org/10.28945/1952).
- Groenvynck, H., K. Vandevelde, and R. Van Rossem. 2013. "The PhD Track: Who Succeeds, who Drops out?" *Research Evaluation* 22 (4): 199–209. doi:[10.1093/reseval/rvt010](https://doi.org/10.1093/reseval/rvt010).
- Gross, J. J., and O. P. John. 2003. "Individual Differences in two Emotion Regulation Processes: Implications for Affect, Relationships, and Well-Being." *Journal of Personality and Social Psychology* 85 (2): 348–362. doi:[10.1037/0022-3514.85.2.348](https://doi.org/10.1037/0022-3514.85.2.348).
- Gruzdev, I., E. Terentev, and Z. Dzhaferova. 2020. "Superhero or Hands-off Supervisor? An Empirical Categorization of PhD Supervision Styles and Student Satisfaction in Russian Universities." *Higher Education* 79 (5): 773–789. doi:[10.1007/s10734-019-00437-w](https://doi.org/10.1007/s10734-019-00437-w).
- Harackiewicz, J. M., E. A. Canning, Y. Tibbetts, C. J. Giffen, S. S. Blair, D. I. Rouse, and J. S. Hyde. 2014. "Closing the Social Class Achievement gap for First-Generation Students in Undergraduate Biology." *Journal of Educational Psychology* 106 (2): 375–389. doi:[10.1037/a0034679](https://doi.org/10.1037/a0034679).
- Harackiewicz, J. M., E. A. Canning, Y. Tibbetts, S. J. Priniski, and J. S. Hyde. 2016. "Closing Achievement Gaps with a Utility-Value Intervention: Disentangling Race and Social Class." *Journal of Personality and Social Psychology* 111: 745–765. doi:[10.1037/pspp0000075](https://doi.org/10.1037/pspp0000075).
- Hardeman, R. R., J. M. Przedworski, S. E. Burke, D. J. Burgess, S. M. Phelan, J. F. Dovidio, ... M. van Ryn. 2015. "Mental Well-Being in First Year Medical Students: A Comparison by Race and Gender." *Journal of Racial and Ethnic Health Disparities* 2 (3): 403–413. doi:[10.1007/s40615-015-0087-x](https://doi.org/10.1007/s40615-015-0087-x).
- Hospel, V., and B. Galand. 2016. "Are Both Classroom Autonomy Support and Structure Equally Important for Students' Engagement? A Multilevel Analysis." *Learning and Instruction* 41: 1–10. doi:[10.1016/j.learninstruc.2015.09.001](https://doi.org/10.1016/j.learninstruc.2015.09.001)
- Houben, M., W. Van Den Noortgate, and P. Kuppens. 2015. "The Relation Between Short-Term Emotion Dynamics and Psychological Well-Being: A Meta-Analysis." *Psychological Bulletin* 141 (4): 901–930. doi:[10.1037/a0038822](https://doi.org/10.1037/a0038822).
- Hu, L. T., and P. M. Bentler. 1999. "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives." *Structural Equation Modeling: a Multidisciplinary Journal* 6 (1): 1–55. doi:[10.1080/10705519909540118](https://doi.org/10.1080/10705519909540118).
- Jairam, D., and D. H., Jr. Kahl. 2012. "Navigating the Doctoral Experience: The Role of Social Support in Successful Degree Completion." *International Journal of Doctoral Studies* 7: 311–329. doi:[10.28945/1700](https://doi.org/10.28945/1700).
- Jang, H., J. Reeve, and E. L. Deci. 2010. "Engaging Students in Learning Activities: It is not Autonomy Support or Structure but Autonomy Support and Structure." *Journal of Educational Psychology* 102 (3): 588–600. doi:[10.1037/a0019682](https://doi.org/10.1037/a0019682).
- Klopp, E. 2019. *A Tutorial on Testing the Equality of Standardized Regression Coefficients in Structural Equation Models using Wald Tests with Lavaan*. doi: [10.31234/osf.io/c6mjn](https://doi.org/10.31234/osf.io/c6mjn).
- Leslie, S.-J., A. Cimpian, M. Meyer, and E. Freeland. 2015. "Expectations of Brilliance Underlie Gender Distributions Across Academic Disciplines." *Science* 347 (6219): 23–34. doi:[10.1081/E-EWS](https://doi.org/10.1081/E-EWS).
- Levecque, K., F. Anseel, A. De Beuckelaer, J. Van der Heyden, and L. Gisle. 2017. "Work Organization and Mental Health Problems in PhD Students." *Research Policy* 46 (4): 868–879. doi:[10.1016/j.respol.2017.02.008](https://doi.org/10.1016/j.respol.2017.02.008).
- Lin, L. C., P. H. Huang, and L. J. Weng. 2017. "Selecting Path Models in SEM: A Comparison of Model Selection Criteria." *Structural Equation Modeling: A Multidisciplinary Journal* 24 (6): 855–869. doi:[10.1080/10705511.2017.1363652](https://doi.org/10.1080/10705511.2017.1363652).

- Mallinckrodt, B., W. T. Abraham, M. Wei, and D. W. Russell. 2006. "Advances in Testing the Statistical Significance of Mediation Effects." *Journal of Counseling Psychology* 53: 372–378. doi:10.1037/0022-0167.53.3.372.
- Martell, R. F., D. M. Lane, and C. Emrich. 1996. "Male-female Differences: A Computer Simulation." *American Psychologist* 51 (2): 157–158. doi:10.1037/0003-066X.51.2.157.
- Martinsuo, M., and V. Turkulainen. 2011. "Personal Commitment, Support and Progress in Doctoral Studies." *Studies in Higher Education* 36 (1): 103–120. doi:10.1080/03075070903469598.
- Masteakaasa, A. 2005. "Gender Differences in Educational Attainment: The Case of Doctoral Degrees in Norway." *British Journal of Sociology of Education* 26 (3): 375–394. doi:10.1080/01425690500128908.
- McAlpine, L., and M. Mitra. 2015. "Becoming a Scientist: Phd Workplaces and Other Sites of Learning." *International Journal of Doctoral Studies* 10: 111–128. doi:10.28945/2112.
- Meyer, M., A. Cimpian, and S.-J. Leslie. 2015. "Women are Underrepresented in Fields Where Success is Believed to Require Brilliance." *Frontiers in Psychology* 6 (March): 1–13. doi:10.3389/fpsyg.2015.00235.
- Murphy, M. C., C. M. Steele, and J. J. Gross. 2007. "Signaling Threat." *Psychological Science* 18 (10): 879–885. doi:10.1111/j.1467-9280.2007.01995.x.
- Neff, K. D. 2003. "The Development and Validation of a Scale to Measure Self-Compassion." *Self and Identity* 2 (3): 223–250. doi:10.1080/15298860309027.
- Nerdrum, P., T. Rustøen, and M. H. Rønnestad. 2006. "Student Psychological Distress: A Psychometric Study of 1750 Norwegian 1st-Year Undergraduate Students." *Scandinavian Journal of Educational Research* 50 (1): 95–109. doi:10.1080/00313830500372075.
- Neuville, S., M. Frenay, J. Schmitz, G. Boudrenghien, B. Noël, and V. Wertz. 2007. "Tinto's Theoretical Perspective and Expectancy-Value Paradigm: A Confrontation to Explain Freshmen's Academic Achievement." *Psychologica Belgica* 47 (1), doi:10.5334/pb-47-1-31.
- O'Connor, P., C. O'Hagan, E. S. Myers, L. Baisner, G. Apostolov, I. Topuzova, G. Saglam, M. G. Tan, and H. Caglayan. 2020. "Mentoring and Sponsorship in Higher Education Institutions: Men's Invisible Advantage in STEM?" *Higher Education Research & Development* 39 (4): 764–777. doi:10.1080/07294360.2019.1686468.
- Olivier, E., B. Galand, A. J. Morin, and V. Hospel. 2021. "Need-supportive Teaching And Student Engagement in the Classroom: Comparing the Additive, Synergistic, and Global Contributions." *Learning and Instruction* 71: 101389. doi:10.1016/j.learninstruc.2020.101389
- O'Meara, K., K. Knudsen, and J. Jones. 2013. "The Role of Emotional Competencies in Faculty-Doctoral Student Relationships." *The Review of Higher Education* 36 (3): 315–347. doi:10.1353/rhe.2013.0021.
- Overall, N. C., K. L. Deane, and E. R. Peterson. 2011. "Promoting Doctoral Students' Research Self-Efficacy: Combining Academic Guidance with Autonomy Support." *Higher Education Research & Development* 30 (6): 791–805. doi:10.1080/07294360.2010.535508.
- Paglis, L. L., S. G. Green, and T. N. Bauer. 2006. "Does Adviser Mentoring add Value? A Longitudinal Study of Mentoring and Doctoral Student Outcomes." *Research in Higher Education* 47 (4): 451–476. doi:10.1007/s11162-005-9003-2.
- Putnick, D. L., and M. H. Bornstein. 2016. "Measurement Invariance Conventions and Reporting: The State of the art and Future Directions for Psychological Research." *Developmental Review* 41: 71–90. doi:10.1016/j.dr.2016.06.004.
- Ryan, R. M., and E. L. Deci. 2017. *Self-determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. The Guilford Press. doi:10.1521/978.14625/28806
- Schmidt, M., and E. Hansson. 2018. "Doctoral Students' Well-Being: A Literature Review." *International Journal of Qualitative Studies on Health and Well-Being* 13 (1): 1508171. doi:10.1080/17482631.2018.1508171.
- Sommet, N., C. Pulfrey, and F. Butera. 2013. "Did my M.D. Really go to University to Learn? Detrimental Effects of Numerus Clausus on Self-Efficacy, Mastery Goals and Learning." *PLoS ONE* 8 (12): e84178–15. doi:10.1371/journal.pone.0084178.
- Spronken-Smith, R., C. Cameron, and R. Quigg. 2018. "Factors Contributing to High PhD Completion Rates: A Case Study in a Research-Intensive University in New Zealand." *Assessment & Evaluation in Higher Education* 43 (1): 94–109. doi:10.1080/02602938.2017.1298717.
- Stroet, K., M.-C. Opdenakker, and A. Minnaert. 2013. "Effects of Need Supportive Teaching on Early Adolescents' Motivation and Engagement: A Review of the Literature." *Educational Research Review* 9: 65–87. doi:10.1016/j.edurev.2012.11.003.
- Tanaka, J. S. 1993. "Multifaceted Conceptions of fit in Structural Equation Models." In *Testing Structural Equation Models*, edited by K. A. Bollen, and J. S. Long, 10–39. Newbury Park, CA: Sage.
- Vandenberg, R. J., and C. E. Lance. 2000. "A Review and Synthesis of the Measurement Invariance Literature: Suggestions, Practices, and Recommendations for Organizational Research." *Organizational Research Methods* 3 (1): 4–70. doi:10.1177/109442810031002.
- Van den Broeck, A., M. Vansteenkiste, H. De Witte, B. Soenens, and W. Lens. 2010. "Capturing Autonomy, Competence, and Relatedness at Work: Construction and Initial Validation of the Work-Related Basic Need Satisfaction Scale." *Journal of Occupational and Organizational Psychology* 83 (4): 981–1002. doi:10.1348/096317909X481382.
- Van der Haert, M., E. Arias Ortiz, P. Emplit, V. Halloin, and C. Dehon. 2013. "Are Dropout and Degree Completion in Doctoral Study Significantly Dependent on Type of Financial Support and Field of Research?" *Studies in Higher Education* 39 (10): 1885–1909. doi:10.1080/03075079.2013.806458.

- Van Der Heijde, C. M., L. Douwes, and P. Vonk. 2019. "Mental Health Problems and Support Needs of PhD Students: Bottle Necks of the PhD Trajectory." *European Journal of Public Health* 29), doi:[10.1093/eurpub/ckz186.588](https://doi.org/10.1093/eurpub/ckz186.588).
- Van der Linden, N., C. Devos, G. Boudrenghien, M. Frenay, A. Azzi, O. Klein, and B. Galand. 2018. "Gaining Insight Into Doctoral Persistence: Development and Validation of Doctorate-Related Need Support and Need Satisfaction Short Scales." *Learning and Individual Differences* 65: 100–111. doi:[10.1016/j.lindif.2018.03.008](https://doi.org/10.1016/j.lindif.2018.03.008).
- van Rooij, E., M. Fokkens-Bruinsma, and E. Jansen. 2021. "Factors That Influence PhD Candidates' Success: The Importance of PhD Project Characteristics." *Studies in Continuing Education* 43 (1): 48–67. doi:[10.1080/0158037X.2019.1652158](https://doi.org/10.1080/0158037X.2019.1652158).
- Verger, P., J. B. Combes, V. Kovess-Masfety, M. Choquet, V. Guagliardo, F. Rouillon, and P. Peretti-Wattel. 2009. "Psychological Distress in First Year University Students: Socioeconomic and Academic Stressors, Mastery and Social Support in Young men and Women." *Social Psychiatry and Psychiatric Epidemiology* 44 (8): 643–650. doi:[10.1007/s00127-008-0486-y](https://doi.org/10.1007/s00127-008-0486-y).
- Visser, M. S., M. Luwel, and H. F. Moed. 2007. "The Attainment of Doctoral Degrees at Flemish Universities: A Survival Analysis." *Higher Education* 54 (5): 741–757. doi:[10.1007/s10734-006-9021-9](https://doi.org/10.1007/s10734-006-9021-9).
- Ward, M. D., and J. S. Ahlquist. 2018. *Maximum Likelihood for Social Science: Strategies for Analysis*. Cambridge University Press.
- Wollast, R., G. Boudrenghien, N. Van der Linden, B. Galand, N. Roland, C. Devos, M. de Clercq, A. Azzi, O. Klein, and M. Frenay. 2018. "Who are the Doctoral Students who Drop out? Factors Associated with the Rate of Doctoral Degree Completion in Universities." *International Journal of Higher Education* 7 (4): 143–156. doi:[10.5430/ijhe.v7n4p143](https://doi.org/10.5430/ijhe.v7n4p143).
- Wollast, R., E. Lacourse, G. Mageau, M. Pelletier-Dumas, A. Dorfman, V. Dupéré, J.-M. Lina, D. Stolle, and R. de la Sablonnière. 2023. "Compassionate Self-Responding in Canadian Adults During the First 8 Months of the COVID-19 Pandemic: A Person-Oriented Multi-Trajectory Approach." *Manuscript Under Review*.
- Wollast, R., A. R. Riemer, P. Bernard, C. Leys, I. Kotsou, and O. Klein. 2019. "How Self-Compassion Moderates the Effect of Body Surveillance on Subjective Happiness and Depression among Women." *Scandinavian Journal of Psychology*, Advance online publication. doi:[10.1111/sjop.12553](https://doi.org/10.1111/sjop.12553).
- Wollast, R., A. R. Riemer, S. J. Gervais, L. Grigoryan, P. Bernard, and O. Klein. 2020a. "How Cultural Orientation and Self-Compassion Shape Objectified Body Consciousness for Women from America, Belgium, Russia, and Thailand." *Self and Identity*, Advance online publication. doi:[10.1080/15298868.2020.1787220](https://doi.org/10.1080/15298868.2020.1787220).
- Wollast, R., A. R. Riemer, E. Sarda, B. M. Wiernik, and O. Klein. 2020b. "How Self-Compassion Moderates the Relation Between Body Surveillance and Body Shame Among Men and Women." *Mindfulness* 11 (10): 2298–2313. doi:[10.1007/s12671-020-01448-w](https://doi.org/10.1007/s12671-020-01448-w).
- World Health Organization. 2004. *Promoting Mental Health: Concepts, Emerging Evidence, Practice* (Summary Report). World Health Organization.
- Zhao, C., C. M. Golde, and A. C. McCormick. 2007. "More Than a Signature: How Advisor Choice and Advisor Behaviour Affect Doctoral Student Satisfaction." *Journal of Further and Higher Education* 31 (3): 263–281. doi:[10.1080/03098770701424983](https://doi.org/10.1080/03098770701424983).