



# Pathways to performance in undergraduate medical students: role of conscientiousness and the perceived educational environment

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## Abstract

This study examined conscientiousness and the perceived educational environment as independent and interactive predictors of medical students' performance within Biggs' theoretical model of learning. Conscientiousness, the perceived educational environment, and learning approaches were assessed at the beginning of the third year in 268 medical students at the University of Geneva, Switzerland. Performance was examined at the end of the third year via a computer-based assessment (CBA) and the Objective Structured Clinical Examination (OSCE). Path analysis was used to test the proposed model, whereby conscientiousness and the perceived educational environment predicted performance directly and indirectly via students' learning approaches. A second model included interaction effects. The proposed model provided the best fit and explained 45% of the variance in CBA performance, and 23% of the variance in OSCE performance. Conscientiousness positively predicted CBA performance directly ( $\beta = 0.19$ ,  $p < 0.001$ ) and indirectly via a deep learning approach ( $\beta = 0.05$ ,  $p = 0.012$ ). The perceived educational environment positively predicted CBA performance indirectly only ( $\beta = 0.02$ ,  $p = 0.011$ ). Neither conscientiousness nor the perceived educational environment predicted OSCE performance. Model 2 had acceptable, but less optimal fit. In this model, there was a significant cross-over interaction effect ( $\beta = 0.16$ ,  $p < 0.01$ ): conscientiousness positively predicted OSCE performance when perceptions of the educational environment were the most positive, but negatively predicted performance when perceptions were the least positive. The findings suggest that both conscientiousness and perceptions of the educational environment predict CBA performance. Research should further examine interactions between personality traits and the medical school environment to inform strategies aimed at improving OSCE performance.

**Keywords** Academic performance · Conscientiousness · Learning approaches · Medical school · Objective structured clinical exam · Perceived educational environment · Undergraduate medical students

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## Introduction

There has been a long-standing research focus on factors that predict academic performance during medical school (Ferguson et al., 2002), and for good reason. Performance in the early years of medical school predicts residency performance (Lee & Vermillion, 2018), performance on the Medical Licensing Exam (Rubright et al., 2019), likelihood of student dropout (O'Neill et al., 2011), and risk for professional misconduct (Papadakis et al., 2005; Yates & James, 2010). Identifying pathways through which factors predict medical student performance remains a priority in medical education research.

Biggs' 3P (Presage-Process-Product) model of learning (Biggs, 1993a) is an influential model in the field of higher education, and provides a framework for examining pathways to student performance. The model posits that students adopt qualitatively different approaches to learning (process factors), which vary as a function of intra-personal presage factors (including prior ability, sociodemographic characteristics, and personality), and contextual presage factors (including the teaching and learning environment). Presage factors may influence performance outcomes (product factors) directly, and/or indirectly via process factors. Research based on the 3P model has typically identified two approaches to learning: (1) A deep learning approach, whereby students conceptually analyze and draw meaning from the learning materials, often driven by an intrinsic interest in the topic. (2) A surface approach, whereby students use strategies that will meet the minimum requirements needed to complete the task, often motivated by extrinsic factors such as the need to pass a test (Biggs, 1993b; Biggs et al., 2001). In addition to direct and indirect predictive effects proceeding from presage to process to product, the model proposes that there are feedback relationships between each stage: products affect future process and presage variables, and process variables can affect some presage variables.

The original 3P model has been expanded to include students' perceptions of their educational environment, proposing that the medical school environment influences students' perceptions, which in turn influence their learning approaches, and ultimately their performance (Price, 2014; Price & Richardson, 2004). Indeed, students with more positive perceptions of the educational environment (including their perception of workload, relevance of teaching to professional practice, and social support systems within the school) are more intrinsically motivated (Muller & Louw, 2004), adopt deeper approaches to learning (Baeten et al., 2010), and perform better in medical school (Wayne et al., 2013) than students with less favourable perceptions.

Research examining predictors of student learning approaches and performance outcomes within the 3P framework has largely developed along two strands: the first focuses on student characteristics such as personality (Chamorro-Premuzic & Furnham, 2008; Diseth, 2003; Duff et al., 2004; Komaraju et al., 2011); the second on student perceptions of the educational environment (Entwistle, 2009; Ramsden, 1991). This division may reflect the idea that student characteristics and contextual factors are unique influences on approaches to learning (Biggs 1987; Newble & Entwistle 1986; Sadlo & Richardson, 2003). However, for a comprehensive understanding of pathways leading to performance, researchers should incorporate both student characteristics and aspects of the learning environment into their analysis models.

Just two studies have incorporated both personality and the perceived educational environment as presage factors in tests of the 3P model of learning (Ginns et al., 2014, 2018). Using data from Australian high-school students, these studies found that both the perceived educational environment (perceived teaching support) and personality

(conscientiousness) had direct effects on product outcomes (class participation, homework completion, and educational aspirations), as well as indirect effects on the same product outcomes via elaboration and memorization. There are no such studies in the context of medical student performance, and no studies have examined potential interactions between these factors. Both personality and the perceived educational environment have been identified as key predictors of medical student performance (Doherty & Nugent 2011; Wayne et al., 2013), and it is important to understand factors that may mediate this association. Moreover, the interaction of individual- and context-level factors likely reflects the true complexity of student performance (Gruppen & Stansfield, 2016) and should be formally tested within models of learning.

Typically, research within the 3P framework identifies personality (alongside sociodemographic characteristics, such as age and gender) as a 'hard' presage factor, not easily changed by teaching (Biggs et al, 2001). However, advances in personality theory contrast with this view, drawing on evidence that trait expression is context-dependent, and traits can change over time (Dingemans et al., 2010; Ferguson et al., 2011; Ferguson & Lievens, 2017). For example, there is some evidence that high conscientiousness enhances performance during the pre-clinical years of medical studies (when the learning context is primarily classroom-based, and knowledge is assessed by exams), but not during the clinical years (when students have to apply their knowledge to diagnose and treat patients, requiring greater flexibility of thought) (Ferguson et al., 2014). It is conceivable that the effects of personality on performance will vary according to the perceived educational environment. According to Trait Activation Theory, the behavioral expression of traits depends on the presence of trait-relevant contextual cues (Tett et al., 2013, 2021). Therefore, students may be most likely to perform well when their personality traits facilitate performance, such as when conscientiousness is high, and when they perceive their learning environment to be supportive.

In addition to the gap outlined above, most of the aforementioned studies on the 3P model only examined one-way learning interactions (from presage, to process, to product), without considering reciprocal relationships between presage and process factors, and therefore provided a less robust test of the proposed model (Anderson & Gerbing, 1988; Platt, 1964). Recent cross-sectional and longitudinal studies indicate that student learning approaches can act as presage factors predicting students' experiences of the teaching–learning environment, as well as process factors predicting performance (Fryer & Ginns, 2018; Karagiannopoulou & Milienos, 2015). There is also evidence that personality predicts the perceived educational environment (Gruppen & Stansfield, 2016; Nijhuis et al., 2007), and it is important to consider this pathway to performance.

The main aim of this study was to use Biggs' 3P model as a framework for examining pathways to performance in the context of medical education. Both conscientiousness and student perceptions of the educational environment were incorporated into the tested models, permitting an understanding of their relative and interactive contributions to student performance. The following three questions were addressed:

1. Do conscientiousness and the perceived educational environment have direct effects on performance, as well as indirect effects on performance via learning approaches (the main pathways highlighted in the 3P model)?
2. Are there interactive effects of conscientiousness and the perceived educational environment on learning approaches and performance?

3. Do conscientiousness and learning approaches have direct effects on performance, as well as indirect effects on performance via the perceived educational environment?

It was hypothesized that the findings would be in line with the main pathways highlighted in Biggs' 3P model of learning, corroborating previous research on high-school students (Ginns et al., 2014, 2018). Specifically, it was hypothesized that conscientiousness and the perceived environment would have direct effects on performance, as well as indirect effects on performance via learning approaches. It was also hypothesized that there would be an interactive effect of conscientiousness and the perceived environment on student performance, in line with Trait Activation Theory (Tett et al., 2013; 2021) and findings that the impact of conscientiousness on medical student performance is context-dependent (Ferguson et al., 2014). Specifically, it was hypothesized that performance would be highest among highly conscientious students who perceived their educational environment to be supportive. Finally, based on the evidence available (Fryer & Ginns 2018; Gruppen & Stansfield 2016; Karagiannopoulou & Milienos 2015; Nijhuis et al., 2007), it was hypothesized that both conscientiousness and approaches to learning would have direct effects on performance, as well as indirect effects on performance via perceptions of the educational environment.

## Method

### Participants

Participants were 268 third-year medical students (108 males and 160 females; mean age 21 years (SD = 1.88, range = 17–38 years)) enrolled in the academic selection years 2013–2014, 2014–2015, and 2015–2016 at the University of Geneva, Switzerland. The sample was part of a larger research project at the University of Geneva designed to follow a cohort of medical students throughout the curriculum. Students participated on a voluntary basis, and gave their informed consent before completing the questionnaires. The Chair of the Cantonal Commission for Ethical Research (CCER) designated the study as exempted from formal review, in accordance with the Swiss law.

### Measures

#### Conscientiousness

Conscientiousness was assessed using the French version of the NEO-Five Factor Inventory (NEO-FFI), a self-report questionnaire designed to capture the 'Big Five' personality traits (Costa & McCrae, 1992; Rolland et al., 1998). Twelve items measure conscientiousness, and each item is scored on a 5-point scale (1 = strongly disagree, 5 = strongly agree). Higher scores reflect higher levels of conscientiousness.

#### Perceived educational environment

Student perceptions of the educational environment were captured using a French version of The Dundee Ready Educational Environment Measure (DREEM; (Roff et al., 1997)). The French version used for this study was a professional translation from the validated

English version at the Ottawa University (courtesy of Timothy Willett). This is a 50-item self-report questionnaire, consisting of five subscales: the perceived learning environment (12 items; e.g., “the teaching is student centered”), the perceived teaching environment (11 items; e.g., “the teachers are good at providing feedback to the students”), the perceived atmosphere (12 items; e.g., “the atmosphere motivates me as a learner”), academic self-perceptions (8 items; e.g., “I feel I am being well prepared for my profession”), and social self-perceptions (7 items; e.g., “there is a good support system for students who get stressed”). The total score is the sum of all items, with higher scores reflecting more positive perceptions of the educational environment. The DREEM has been used extensively in the context of medical education (Colbert-Getz et al., 2014), and is reliable across countries, cultures, and settings (Soemantri et al., 2010).

### Learning approaches

Student learning approaches were measured using a French version of the Revised Two-Factor Study Process Questionnaire (R2-SPQ) (Biggs et al., 2001). A French version of the questionnaire was not available at the time of the study, therefore the items were translated into French and back-translated into English by two independent reviewers. The questionnaire comprises 20 items, each scored on a 5-point scale (1 = this item is never or only rarely true of me, 5 = this item is always or almost always true of me). Ten items assess a deep learning approach (e.g., “I find most new topics interesting and often spend extra time trying to obtain more information about them”), and 10 items assess a surface learning approach (e.g., “I find I can get by in most assessments by memorizing key sections rather than trying to understand them”).

### Performance

The medical school curriculum at the University of Geneva consists of a 3-year Bachelor program and a 3-year Master program. In the third year of the bachelor program, there are summative assessments at the end of each module (twice per year). Module 3 (Introduction to the nervous system; Neurosciences) is assessed at the end of the first semester, and module 4 (Defence and immunity; Infections) is assessed at the end of the second semester. Assessments include computer-based written exams (CBAs), and Objective Structured Clinical Exams (OSCEs). The CBAs cover the topics taught during the module, using vignettes and multiple-choice questions. The OSCE is an oral exam assessing clinical skills taught in the second and third years of the Bachelor. Students pass three stations with standardized simulated patients.

Student performance on the CBA of module 4, and their performance on the OSCE were the main outcome variables in this study. These outcomes were assessed at the end of the second semester, after the students had completed the self-report questionnaires (on conscientiousness, the perceived educational environment, and learning approaches). Module 3 CBA performance was assessed before the self-report questionnaires; therefore, this was included as a covariate rather than an outcome variable.

### Covariates

The 3P model identifies sociodemographic characteristics (including age, gender, and parental education), and previous performance, as additional presage factors relevant to

performance outcomes. Indeed, these sociodemographic characteristics have been associated with student learning approaches and performance (Richardson, 2006; Richardson et al., 2012), and previous performance is a strong predictor of future performance (Stegers-Jager et al., 2015). These factors were therefore included as covariates. Parental education level (highest obtained level of mother and father) was categorized as lower (no qualifications, high-school education, or vocational education), or higher (university education). Performance on the CBA at the end of the first semester (assessing module 3) was used as a recent measure of prior performance. Repeater status (whether or not the student had re-taken the first year of medical school) was also included as a covariate.

## Statistical analyses

Path analysis was used to examine presage factors as predictors of product factors in 3 proposed models. Model 1 examined conscientiousness and the perceived educational environment as presage factors predicting performance directly and indirectly via student learning approaches. Model 2 added an interaction term (conscientiousness X perceived environment) to model 1 to test for potential moderating mechanisms. Model 3 examined conscientiousness and learning approaches as presage factors predicting performance directly and indirectly via the perceived educational environment.

Model fit was assessed using the root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). As recommended (Kline 2015),  $RMSEA < 0.06$ ,  $CFI > 0.95$ , and  $TLI > 0.95$  were taken to indicate acceptable model fit. Akaike's information criterion (AIC) was used to determine which model fitted the data best, with lower values indicating better fit.

Indirect (mediated) effects were tested using bootstrapping with 2000 iterations, and 95% confidence intervals were calculated. The variables that were used in the interaction term (conscientiousness and the perceived environment) were mean centered before multiplication for ease of interpretation. Interaction effects were probed using simple slope analysis. Each model included age, gender, parental education level, and prior performance as covariates.

Direct and indirect effects were interpreted in terms of the magnitude of the standardized beta coefficients, using the benchmarks proposed by (Keith 2014):  $> 0.05$  is a small but meaningful direct effect,  $> 0.10$  is a moderate direct effect, and  $> 0.25$  is a large direct effect. As an indirect effect is the product of two effects (Kenny 2021), 0.003 ( $0.05 \times 0.05$ ) can be considered as a small but meaningful indirect effect, 0.01 ( $0.10 \times 0.10$ ) as a moderate indirect effect, and 0.06 ( $0.25 \times 0.25$ ) as a large indirect effect.

All analyses were carried out using SPSS and Amos Version 25 for Windows (SPSS Inc., Chicago, IL).

## Results

### Preliminary analyses

Data were obtained from 268 individuals. In this sample, the internal consistency of all questionnaire measures was high (Cronbach's alphas = 0.86, 0.91, 0.79, and 0.75 for conscientiousness, DREEM, and deep and surface learning approaches, respectively). There were some missing data for 15 individuals ( $\leq 15$  cases without performance data; 15 cases

without parental education information). Little's test applied to these variables was not significant ( $\chi^2=3.44$ ,  $df=2$ ,  $p=0.179$ ), suggesting the data were missing completely at random. Missing data were therefore imputed using the maximum likelihood estimation method.

Half of the sample were repeaters, and around three-quarters of the sample had at least one parent educated to university level. As shown in Table 1, both conscientiousness and the perceived educational environment were associated with students' deep and surface learning approaches, and performance on the CBA (all  $p$  values  $<0.01$ ). Repeater status, prior performance, and a deep learning approach were also associated with performance on the CBA (all  $p$  values  $<0.01$ ). Only gender, prior performance, and CBA performance were associated with performance on the OSCE (all  $p$  values  $<0.01$ ).

All correlations between variables to be included as presage factors in the models were small to moderate ( $r$  range 0.13–0.62), indicating that multicollinearity was not an issue. All variables to be included in the models were normally distributed (skewness  $<1$ , kurtosis  $\leq 2$ ).

## Path analysis

Model 1 had acceptable fit:  $\chi^2(2)=0.23$ ,  $p=0.89$ , CFI=1.00, TLI=1.11, RMSEA=0.00. Model 2 (with the added interaction term) also fitted the data:  $\chi^2(2)=0.23$ ,  $p=0.89$ , CFI=1.00, TLI=1.12, RMSEA=0.00. However, model 1 had a lower AIC value than model 2 (150.23 vs. 176.23), suggesting better fit. Model 3 did not fit the data:  $\chi^2(1)=4.49$ ,  $p=0.03$ , CFI=0.99, TLI=0.65, RMSEA=0.11. Table 2 provides the standardized beta ( $\beta$ ) coefficients for direct and indirect associations among presage, process, and product variables in model 1.

## Model 1

Figure 1 depicts model 1, along with significant paths. In model 1, the presage variables accounted for 29% of variance in deep learning approach, and 17% of variance in surface learning approach. The presage and process variables accounted for 45% of variance in CBA performance, and 23% of variance in OSCE performance.

In terms of direct effects, conscientiousness and the perceived educational environment positively predicted a deep learning approach, with large effect sizes ( $\beta = 0.35$  and  $0.30$ , respectively); and negatively predicted a surface learning approach, with a moderate effect size for conscientiousness ( $\beta = -0.14$ ) and a large effect size for the perceived educational environment ( $\beta = -0.36$ ). A deep learning approach moderately predicted CBA performance ( $\beta = 0.12$ ), but not OSCE performance. Conscientiousness, but not the perceived educational environment, directly predicted CBA performance, with a moderate effect size ( $\beta = 0.19$ ). Neither conscientiousness nor the perceived educational environment directly predicted OSCE performance. Performance in the previous semester directly and strongly predicted both CBA and OSCE performance ( $\beta = 0.57$  and  $0.32$ , respectively). In terms of covariates, age positively and moderately predicted a deep learning approach ( $\beta = 0.14$ ). There was also a large effect of gender on OSCE performance ( $\beta = 0.35$ ), with females performing better than males.

In terms of indirect effects, there was a moderate to large indirect path from conscientiousness through a deep learning approach to CBA performance ( $\beta = 0.05$ ; 95% CI

**Table 1** Descriptive statistics and correlations for variables included in the models (N = 268)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
	<i>M (SD)</i>									
1. Age	20.80 (1.88)									
2. Gender, % (n) male	-0.02	40.30 (108)								
3. Parental education, % (n) university	0.01	-0.01	76.87 (206)							
4. Repeater status, % (n) repeater	0.19*	0.08	-0.05	50.37 (135)						
5. Prior performance	0.02	-0.06	0.07	-0.30**	71.49 (8.10)					
6. Conscientiousness	0.02	0.08	-0.07	0.03	0.16**	33.27 (7.00)				
7. Deep learning approach	0.13*	0.02	-0.08	-0.00	0.12	0.45**				
8. Surface learning approach	-0.05	-0.02	-0.02	0.05	-0.03	-0.24**	-0.38**			
9. Perceived educational environment	-0.04	-0.07	0.05	-0.20**	0.19**	0.29**	0.38**	-0.38**		
10. CBA performance	0.01	-0.00	-0.02	-0.22**	0.62**	0.32**	0.25**	-0.07	0.18**	
11. OSCE performance	-0.06	0.32**	-0.06	-0.12*	0.29**	0.02	-0.06	0.00	0.04	0.25**

CBA computer-based assessment, OSCE Objective Structured Clinical Examination

Values are means (standard deviations), unless stated otherwise

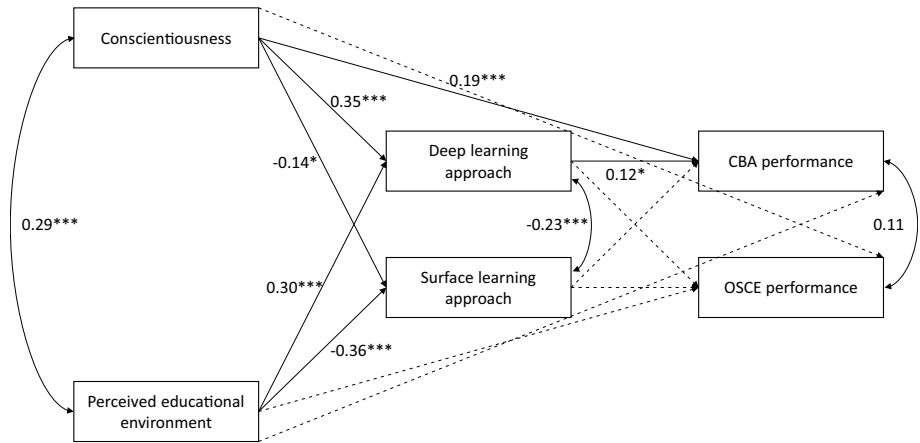
\* $p < 0.05$ , \*\* $p < 0.01$



**Table 2** Standardized beta coefficients for model 1

Presage factors	Process factors		Product factors					
	SA		CBA		OSCE			
	Direct effect	Direct effect	Direct effect	Indirect effect via DA	Indirect effect via SA	Direct effect		
Age	0.14*	-0.05	-0.01	0.18*	-0.02	-0.02	-0.15	0.01
Gender	0.02	-0.03	0.02	0.04	-0.02	0.35***	-0.03	0.01
Parental education	-0.06	-0.02	-0.04	-0.16	-0.02	-0.10	0.13	0.01
Prior performance	0.02	0.05	0.57***	0.00	0.00	0.32***	-0.00	-0.00
Conscientiousness	0.35***	-0.14*	0.19***	0.05*	-0.01	-0.04	-0.04	0.00
Perceived educational environment	0.30***	-0.36***	-0.02	0.02*	-0.01	0.06	-0.02	0.00

DA deep learning approach, SA surface learning approach, CBA computer-based assessment, OSCE objective structured clinical examination  
 \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

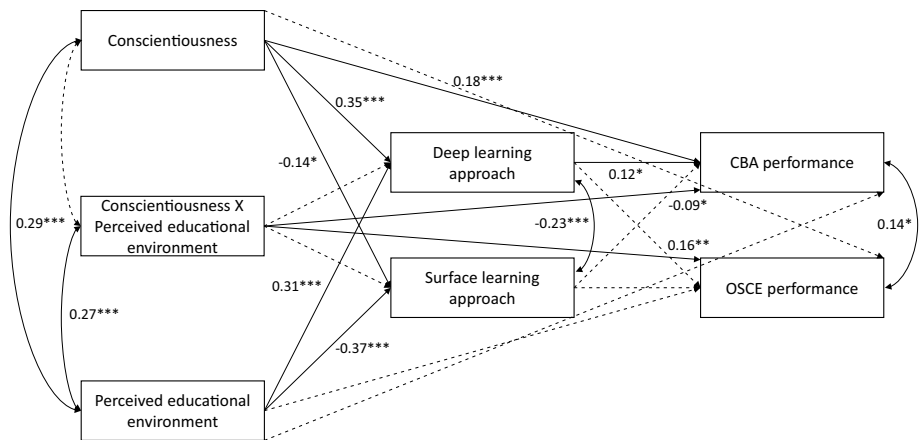


**Fig. 1.** Paths tested within Model 1. Standardized coefficients are included for statistically significant paths. Dashed lines indicate non-significant paths. Covariates are not included for readability. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .  $N = 268$

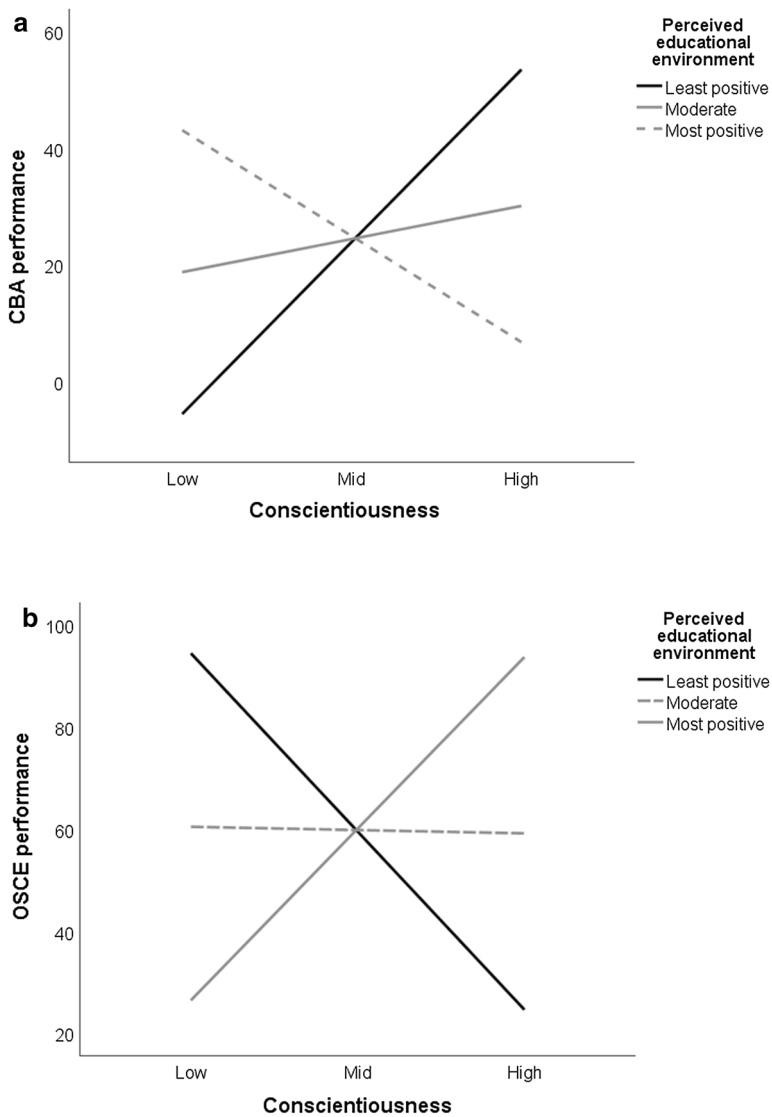
0.01–0.11). There was also a moderate path from the perceived educational environment through a deep learning approach to CBA performance ( $\beta = 0.02$ ; 95% CI 0.00–0.04).

**Model 2**

Figure 2 depicts model 2, along with significant paths. Figure 3 depicts the interaction effects. For model 2, the parameter estimates were almost identical to those for model 1. In addition to the effects outlined for model 1, there was a moderate direct interaction effect (conscientiousness X perceived educational environment) on CBA and OSCE performance



**Fig. 2.** Paths tested within Model 2. Standardized coefficients are included for statistically significant paths. Dashed lines indicate non-significant paths. Covariates are not included for readability. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .  $N = 268$



**Fig. 3.** Mean CBA and OSCE performance at each level of conscientiousness (low = 1SD below the mean, moderate = average, and high = 1SD above the mean) by each level of the perceived educational environment (least positive = 1SD below the mean, moderate = average, and most positive = 1SD above the mean). Bold lines indicate significant effects of conscientiousness on performance at the  $p < 0.05$  level. Dashed lines indicate non-significant effects. CBA computer-based assessment, OSCE objective structured clinical examination

( $\beta = -0.09$ ,  $p = 0.05$ ;  $\beta = 0.16$ ,  $p < 0.01$ , respectively). For CBA performance, there was a positive association between conscientiousness and performance when perceptions of the educational environment were the least positive ( $\beta = 1.21$ ; 95% CI 0.14 – 2.37,  $p < 0.05$ ) or moderate ( $\beta = 0.23$ ; 95% CI 0.10–0.36,  $p < 0.01$ ), but there was no significant association when perceptions of the educational environment were the most positive ( $\beta = -0.75$ ;

95% CI  $-1.89$  to  $0.31$ ,  $p = 0.17$ ). For OSCE performance, there was a positive association between conscientiousness and performance when perceptions of the educational environment were the most positive ( $\beta = 1.38$ ; 95% CI  $0.29$ – $2.41$ ,  $p < 0.05$ ), a negative association when perceptions of the educational environment were the least positive ( $\beta = -1.43$ ; 95% CI  $-2.55$  to  $-0.33$ ,  $p < 0.05$ ), and no significant association when perceptions were moderate ( $\beta = -0.03$ ; 95% CI  $-0.17$  to  $0.11$ ,  $p = 0.68$ ). The interaction term accounted for an additional 1% in the statistical prediction of CBA performance, and an additional 2% in the statistical prediction of OSCE performance.

## Discussion

This is the first study to examine conscientiousness and the perceived educational environment as independent and interactive predictors of performance in medical school. Model 1, which tested the main pathways in the 3P model (Biggs, 1993a), provided the best fit to the data. Both conscientiousness and the perceived educational environment predicted performance on the computer-based assessment (CBA) at the end of the third year, via a deep learning approach. Neither conscientiousness nor the perceived educational environment independently predicted performance on the Objective Structured Clinical Examination (OSCE). Model 2, with the added interaction terms, had acceptable but less optimal fit to the data compared with model 1. In this model, there was a cross-over interaction effect: conscientiousness positively predicted OSCE performance among students with the most positive perceptions of the educational environment, but negatively predicted performance among those with the least positive perceptions of the educational environment. There was also a significant interaction effect for CBA performance, but in a different direction: conscientiousness positively predicted performance among those with the least positive or moderate perceptions of the educational environment, but there was no effect of conscientiousness among those with the most positive perceptions. Taken together, these findings highlight the importance of considering both student characteristics and perceptions of the educational context when investigating predictors of performance.

Consistent with the main pathways proposed in the 3P model (Biggs, 1993a), conscientiousness (an intra-personal presage factor), and the perceived educational environment (a contextual presage factor) predicted CBA performance directly, and/or indirectly via a deep approach to learning (a process factor). These findings corroborate previous research examining high-school students' performance within the 3P framework (Ginns et al., 2014, 2018), and provide further support that a deep approach to learning positively predicts medical students' performance on CBAs (Reid et al., 2007). However, there were no effects of approaches to learning (direct or indirect) on OSCE performance. Some previous studies have found an association between a deep learning approach and clinical exam performance (May et al., 2012; McManus et al., 1998), although several other studies found no association (Arnold & Feighny, 1995; Lohuizen et al., 2009; Martin et al., 2000). A deep learning approach, which has an emphasis on thorough understanding, may be most suited to knowledge acquisition (which is assessed in the CBA). However, it may be less useful for demonstrating clinical and communication skills, which are assessed in the OSCE. Research indicates that students tend to use more than one approach to learning (Lohuizen et al., 2009), and vary their approach according to the assessment context (Newble & Jaeger 1983; Thomas & Bain 1984; Piumatti et al., 2021). In a clinical assessment context, successful students may be more likely to use a combination of strategies that support the

integration of knowledge, skills, and professional behavior. Some research indicates that a strategic approach to learning, which was not assessed in the present study, positively predicts OSCE performance (Martins et al., 2000).

In addition to the main predictive effects (presage to process to product), the 3P model proposes that there are reciprocal relationships between presage, process, and product factors, which operate over time: process variables can predict some presage variables, and outcomes can predict future process and presage variables. In the present study, model 3 (which identified learning approaches and conscientiousness as predictors of the perceived educational environment) did not adequately fit the data. In model 1, performance in the previous semester was strongly associated with a deep learning approach and both CBA and OSCE performance at the end of the third year. However, longitudinal studies are needed to provide a robust test of reciprocal relationships between presage and product factors (Fryer & Ginns, 2018).

The findings of this study extend previous research by examining interactive effects of personality and the perceived educational environment on medical student performance. No known studies have examined how the perceived educational environment might moderate the effects of personality on performance, therefore it is not possible to make direct comparisons. However, some previous work has shown that the effects of conscientiousness on performance vary according to the medical school context, with conscientiousness positively predicting pre-clinical, but not clinical knowledge (Ferguson et al., 2003, 2014). The present findings suggest that both conscientiousness and perceptions of the educational environment need to be high to enhance OSCE performance; but conscientiousness is sufficient to enhance CBA performance even among those who have lower perceptions of the educational environment. Perhaps this can be partly explained by the different demands of the CBA and OSCE: conscientiousness can enhance performance when the task is suited to learning facts and a methodological approach (as in the CBA), but is insufficient when the task is more complex, requiring knowledge application and communication skills (such as in a clinical assessment context). Taken together, these findings are in line with Trait Activation Theory, according to which the behavioral expression of traits depends on the presence of trait-relevant contextual cues (Tett et al, 2013; 2021). However, it is important to note that the interaction effects explained a small proportion of variance in CBA and OSCE performance; therefore, it will be important further examine these effects in a larger sample.

Although the findings of the present study require replication, at face value they highlight the need for strategies to enhance both conscientiousness and perceptions of the educational environment. Selecting students who score highly on conscientiousness upon entry to medical school is limited given that traits change over time and their expression is context-dependent (Ferguson & Lievens, 2017). Some research indicates that performing trait-typical behaviors predicts trait change over time (Hudson et al., 2019; Hudson & Fraley, 2015); however, no research has examined whether personality management could be included as part of medical education. Stress-management interventions, and/or those that enhance students' self-efficacy may improve performance (Shapiro et al., 2000; Stegers-Jager et al., 2012). A student-centered learning environment should take perceived contextual factors into account by providing support, from both an academic and social perspective. Setting clear goals, highlighting the value of educational activities, encouraging participation, providing possibilities for independent study, and maintaining an appropriate workload and information load are factors that can enhance motivation and performance (Baeten et al., 2010; Pelaccia and Viau 2017). Students can be supported socially through learning communities, which may help them find more connections through

medical school (Ferguson et al., 2009). Research has shown that perceptions of the educational environment are more positive at medical schools with learning communities than at those without (Smith et al., 2016). Providing adequate support during the transition from pre-clinical to clinical studies may be particularly important for students' academic performance and well-being. Some research indicates that perceptions of the educational environment decline the most during the third year, as students transition to the clinical phase of medical training (Dunham et al., 2017).

## Limitations and suggestions for future research

This study focused on the personality trait conscientiousness, which has been the most consistently linked to medical student performance in the literature (Doherty & Nugent 2011; Lievens et al., 2002, 2009). Nevertheless, other traits such as extraversion and openness have been linked to performance, especially during the clinical years of medical school (Lievens et al., 2009; Sobowale et al., 2018). These traits should be considered in future research testing the models in this study, with larger sample sizes. This study also focused on the perceived educational environment, which is an important but subjective predictor of student performance. It will be important to examine how objective features of the educational environment fit within the tested models. Recent research found that a problem-based-learning environment and an integrated curriculum at medical school were associated with deeper approaches to learning (compared to a lecture-based environment, and a traditional curriculum), and this was mediated by student perceptions of the educational environment (Gustin et al., 2018). Motivational factors should also be considered as potential mediators and moderators of the pathways tested in this study. Student motivation is a key predictor of performance (Kusurkar et al., 2013; Wu et al., 2020), may explain the effect of conscientiousness and/or the perceived educational environment on performance (Pelaccia & Viau 2017; Richardson & Abraham 2009), and may compensate for low conscientiousness and/or less positive perceptions of the educational environment (Cheng & Ickes 2009). Self-report measures may be prone to bias; although research suggests that bias is more prevalent upon entry to medical school, when the stakes are high (Anglim et al., 2018). Finally, the cross-sectional nature of the analyses precludes inferences of causality, therefore future studies should longitudinally examine the models in this study.

## Conclusion

This study examined the independent and interactive effects of conscientiousness and the perceived educational environment in relation to medical students' performance at the end of the third year. Taken together, the findings highlight the importance of jointly considering student traits and context-related factors when supporting medical students to enhance their performance. The identification of interactive effects is a novel finding that requires further investigation.

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## Declarations

**Conflict of interest** The authors have no conflicts of interest to declare that are relevant to the content of this article.

**Ethical approval** The Chair of the Cantonal Commission for Ethical Research (CCER) designated the study as exempted from formal review, in accordance with the Swiss law.

**Consent to participate** Informed consent was obtained from all individual participants included in the study.

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