When Academic Achievement (Also) Reflects Personality: Using the Personality-Achievement Saturation Hypothesis (PASH) to Explain Differential Associations Between Achievement Measures and Personality Traits

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Abstract

Students' academic achievement is a key predictor of various life outcomes and is commonly used for selection as well as for educational monitoring and accountability. With regard to achievement indicators, a differentiation has traditionally been drawn between grades and standardized tests. There is initial, albeit inconclusive, evidence that these indicators might differentially reflect students' personality as encapsulated in the Big Five personality traits as well as measures of cognitive abilities. In this article, we propose the personality-achievement saturation hypothesis (PASH) as an overarching model that describes the association between achievement indicators and personality. The PASH suggests that the differentiation between grades and tests is too simplistic and that associations between personality and achievement instead vary across five main features of the achievement measures that are used: level of standardization, relevance for the student, curricular validity, instructional sensitivity, and cognitive ability saturation. On the basis of findings from prior studies, we focused in particular on conscientiousness and openness to test the PASH. We used data from three large-scale studies (total $N = 14,953$) and aggregated our findings across these studies. In line with the PASH, the Big Five trait of conscientiousness was most strongly related to measures that were less standardized and less saturated with cognitive ability but higher on curriculum validity, relevance, and instructional sensitivity. In addition, openness was most strongly related to measures that were higher on standardization and cognitive ability saturation but lower on relevance, curriculum validity, and instructional sensitivity in English.

Keywords: academic achievement, scholastic achievement, personality traits, test scores, grades, PASH

Educational Impact and Implications Statement

Achievement measures are of central importance for student selection, employment, and educational policy, and according to a widely shared belief, they involve intellectual abilities as well as aspects of personality such as effort and persistence. Up to now, prior research has remained rather inconclusive about why achievement measures vary in their degree of personality saturation. In this study, we developed and successfully tested a new framework (the PASH), which categorizes achievement measures along five main features and thereby contributes to a better explanation of differential associations between personality traits and different achievement measures.

When Academic Achievement (Also) Reflects Personality: Using the Personality-Achievement Saturation Hypothesis (PASH) to Explain Differential Associations Between Achievement Measures and Personality Traits

Both school grades and results from standardized achievement tests are key predictors of various life outcomes such as educational and socioeconomic success or educational transitions and choices (e.g., Göllner et al., 2018; Hanushek & Woessmann, 2010; Kuncel et al., 2001, 2004; Ng et al., 2005). Furthermore, they matter for access to higher education, drop-out, and later employment (Bowers, 2011; Hübner et al., 2020; Richardson et al., 2012; Robbins et al., 2004; Shepard et al., 2005).

The correlation between school grades and scores on standardized achievement measures is far from perfect, suggesting that the two measures might partially tap into different student characteristics that contribute to academic achievement (Willingham et al., 2002). In fact, recent research has suggested that, at least to some extent, these differences might be the result of differential associations between the different achievement measures and personality traits (e.g., Borghans et al., 2016; Lechner et al., 2017; Lüdtke et al., 2004; Muenks et al., 2017; Nofle & Robins, 2007; Spengler et al., 2013). However, the current state of research is far from conclusive, and to our knowledge, no study has yet explicitly theorized, tested, and discussed differences in the predictive power of personality traits across different achievement measures from an educational psychology perspective. In fact, what seems to be missing is a conceptual model that can be used to identify and link features of achievement measures more closely to personality traits.

In the present investigation, we therefore developed and systematically tested the personality-achievement saturation hypothesis (PASH). This hypothesis suggests that—rather than using the traditional dichotomy between grades and standardized tests—the strengths of the personality-achievement association across achievement measures can be explained more thoroughly by considering five central features of achievement measures: standardization,

relevance, curricular validity, instructional sensitivity, and cognitive ability saturation. This is a unique characteristic of the PASH and is currently not part of any other model or theory. The present study is the first to systematically examine the PASH. As most prior studies on associations between measures of academic achievement and personality have found that various achievement measures show substantial associations with openness and conscientiousness but inconsistent and typically small associations with other personality traits (e.g., Poropat, 2009), we decided to focus on these two most prominently researched traits when testing the PASH and discussing the results.

Measures of Students' Academic Achievement

Academic achievement is a central outcome of education processes and is itself a predictor of a variety of short- and long-term outcomes (e.g., Duncan et al., 2007; Göllner et al., 2018; Hanushek & Woessmann, 2010; Kuncel et al., 2001).¹ However, there are important differences between the various achievement measures. The most classical differentiation is between teacher-assigned grades and standardized achievement tests, although—as argued below—a greater level of differentiation might be important for providing a better explanation of the differential associations that personality traits have with achievement measures.

Grading can be roughly defined as assigning symbols to students' work, whereby work can refer to individual exams or combinations of students' previous achievements in a specific course (Brookhart et al., 2016). Teacher-assigned grades are typically understood as multidimensional constructs in the sense that their variation, in addition to reflecting differences in cognitive abilities, is also substantially explained by other individual characteristics such as students' engagement or persistence (Bowers, 2011). *Standardized tests*, in turn, can be defined as tests “with uniform questions, administration, and scoring” (Koretz, 2002, p. 753). Achievement measures based on standardized tests are typically

¹ In this paper, we used the term academic achievement, but other terms exist to describe student achievement (e.g., scholastic achievement) that we consider to be identical throughout this manuscript.

considered to reflect rather unidimensional constructs that are less affected by student characteristics other than cognitive abilities (e.g., Brookhart et al., 2016).

Grades and standardized achievement tests traditionally serve different purposes. Grades have a long tradition related to microlevel management in the classroom but are often criticized for being overly subjective and only loosely related to students' actual cognitive abilities (Bowers, 2011). Compared with grades, the standardized test is a rather novel instrument that has gained popularity in education over the last 30 years (Bowers, 2011). Educational policy has fostered the use of standardized tests as instruments that can provide more meaningful comparisons of students and as a foundation for macrolevel activities such as educational monitoring, school accountability, and educational governance (e.g., Hess & Petrilli, 2006; Volante, 2016).

Grades and test scores are not perfectly related, suggesting that they are influenced by different factors, including different characteristics of students (Bowers, 2011; Brookhart et al., 2016; Dickinson & Adelson, 2015; Willingham et al., 2002). In fact, there has been a long-standing and productive debate about differences between grades and test scores, especially regarding their predictive validity for university or college success (e.g., Brookhart et al., 2016; Kuncel et al., 2005; Thornell & Jones, 1986; Zwick & Sklar, 2005). However, as we will argue in the remainder of this article, the broad labels “grades” and “standardized tests” have been used to describe a large number of fairly heterogeneous achievement measures, potentially obscuring psychologically important differences across and within different measures of “grades” and “standardized achievement tests.” Hence, we argue that it is important to overcome the oftentimes dichotomous perspective on these achievement measures and conceptualize grades and test scores on the basis of five main features: standardization, relevance for the student, curricular validity, instructional sensitivity, and cognitive ability saturation.

To account for these differences among achievement features and, consequently, to better explain the associations between achievement indicators and personality, we developed the PASH, which specifies features of achievement indicators that we believe should be used to study the personality-achievement association. In addition, the PASH encapsulates a set of predictions regarding the associations between these features and personality traits. We next describe the features of achievement measures we deem important, before we go on to describe the assumed differential associations between student characteristics and achievement measures more thoroughly.

Features of Achievement Measures

There are a number of features of achievement measures that go well beyond the tradition of differentiating between grades and standardized tests. In the PASH, five features are used to characterize achievement indicators. Whereas these five features overlap to some degree, they are still distinct enough to warrant their separate consideration when characterizing achievement measures.

The *level of standardization* reflects the degree to which an achievement measure is based on an objective process (e.g., not influenced by teachers' subjective decisions). This basically means that all participants are tested on similar tasks that are administered and scored similarly for each and every examinee (Koretz, 2008). The level of standardization has traditionally been used to differentiate between grades and standardized achievement tests. Typically, grades are assumed to be less standardized as they are strongly based on subjective evaluations of a student by the course teacher in comparison with achievement tests, which follow a common, standardized evaluation protocol.

The *level of relevance* refers to the importance of an achievement measure for the student, for instance, whether or not it has an impact on a student's future life (e.g., university access or employment; high stakes) or not (low stakes; e.g., Au, 2007; Cole & Osterlind, 2008; Ryan & Weinstein, 2009). Therefore, grades can vary in their relevance, suggesting that

some of them are more relevant for students than others (e.g., grades in core subjects or specific grades that count more heavily toward weighted GPAs; Kramer & London, 2006). Standardized achievement tests can also vary in their relevance for students, as reflected, for instance, by the differentiation between assessments that purely serve monitoring purposes (e.g., Programme for International Student Assessment (PISA); Organisation for Economic Co-operation and Development [OECD], 2014) and therefore have low relevance for individual students, versus standardized admission tests such as the American College Testing (ACT) Program or Scholastic Assessment Test (SAT; ACT, 2019; Geiser & Santelices, 2007; Westrick et al., 2015) that are of paramount relevance for individual students.

The level of *curricular validity* mainly captures the degree to which a specific achievement measure represents the content that is part of a student's curriculum (McClung, 1979). Whereas teacher-assigned grades are typically based on student work and assessments that are closely linked to the curriculum, curricular validity might vary between assessment programs. For instance, the Third International Mathematics and Science Study (TIMSS) was based on an international analysis of mathematics curricula and is supposed to be curriculum-valid. By contrast, PISA is more oriented toward general life skills, which might not be an explicit part of the curriculum (Klieme, 2016).

Even if an exam or test is curriculum-valid, it can vary in its level of *instructional sensitivity* (McClung, 1979). This means that achievement measures might be based on tasks or items that are comparable to the tasks that students have been working on in class (higher *instructional sensitivity*) or on new, unknown tasks (lower *instructional sensitivity*; Naumann et al., 2016). The term instructional sensitivity has a long history and has been used inconsistently in the past (Polikoff, 2010). In the current study, it is understood as an achievement measure property that is more or less sensitive to the teaching students received. For instance, grades might vary in their instructional sensitivity if they are based on exams developed by the course teacher versus a larger (possibly external) group of teachers. In the

same vein, standardized achievement tests can be used to assess what was done in class more or less properly (e.g., testing students on a topic that was taught previously in class vs. testing students on a topic that received little to no attention in class or testing with new, unknown task formats). It is important to note that there is not necessarily a strong association between curricular validity and instructional sensitivity: Tests with curricular validity can consist of mixtures of items that either are or are not instructionally sensitive or vary in their degree of instructional sensitivity. A test with curricular validity can still consist of a majority of non-instructionally sensitive items (e.g., Li et al., 2017)

Finally, different achievement measures can be categorized on the basis of their *level of cognitive ability saturation*. Basically, this is related to the question of the extent to which different achievement measures are associated with cognitive abilities. As suggested in prior research, the correlations of general cognitive abilities with either grades or standardized test results are far from perfect (Borghans et al., 2016). In addition, several studies have reported evidence that general cognitive abilities are substantially more strongly correlated with standardized test scores than with grades (e.g., Borghans et al., 2016; Brandt et al., 2019; Meyer et al., 2019). Therefore, it seems important to consider the degree of cognitive ability saturation exhibited by different achievement measures. The need for this feature becomes particularly evident when considering the typically slightly higher associations that cognitive abilities show with math achievement than with achievement in verbal domains (e.g., Roth et al., 2015). It is important to emphasize that seemingly similar achievement measures can vary in their level of standardization, relevance, curricular validity, instructional sensitivity, and cognitive ability saturation within and across social contexts and different educational systems (see Table 1). For instance, in some countries (e.g., Germany), a mixture of upper secondary school course grades and final examination grades with varying features are the major selection criteria for employment or university access (see Table 1). In some countries such as China, a highly standardized test is used to decide who is granted entrance to

prestigious institutions of higher education (Liu, 2013). Some countries (e.g., the United States) base these decision on grades and the results of additional standardized tests (e.g., ACT or SAT; Geiser & Santelices, 2007; Westrick et al., 2015). Still other countries (e.g., England) have come up with mixtures of the two measures in terms of objective and subjective parts (e.g., Thomas et al., 2016). Therefore, rather than sticking with the blurry dichotomy of grades versus standardized tests, as though they are measures with universal properties, the positioning of achievement measures along the aforementioned five features should be carefully reconsidered in each social context. Table 1 shows that the PASH framework, including the categorization of achievement measures along their features, is not limited to a specific context but also applies to prominent measures in other countries (e.g., SAT or AP tests).

Differential Associations between Personality and Different Measures of Academic Achievement

In addition to differentiating among different measures of academic achievement, the PASH provides a framework from which to make predictions regarding these features of achievement and key measures of personality. Put simply, we argue that personality will manifest itself in a more pronounced way (“higher personality saturation”) under certain circumstances that can be described by the five features of achievement indicators described above. In the following, we take prior research and other theoretical approaches into account to develop specific hypotheses. However, we begin by describing how we use the term “personality” in the present article.

Personality: Cognitive abilities and personality traits. When referring to personality, broad taxonomies include individual differences in cognitive abilities as well as personality traits (Revelle, 1995). Cognitive abilities can be understood as the ability to learn new things and solve novel problems (Reeve, 2017). Personality traits are understood as relatively enduring patterns of thoughts, feelings, and behaviors that have been shown to be related to a

broad set of (life) outcomes such as university retention, job performance, career satisfaction, happiness, psychological well-being, physical health, and relationships (Alarcon & Edwards, 2013; Ozer & Benet-Martínez, 2006; Roberts et al., 2007; Sutin et al., 2009). The most frequently applied and studied taxonomy of personality traits is the Five Factor Model (FFM) and the Big Five, both of which contain neuroticism, extraversion, openness, conscientiousness, and agreeableness (John et al., 2008; McCrae & Costa, 1999), the factors that we consider in this manuscript. Note that throughout the manuscript, we use the terms FFM and Big Five synonymously. On the basis of their personality traits, individuals react differently to social situations and physical environments, and these various reactions can have consequences for their lives (Spengler, 2017). Applied to the educational context, a student's personality might help explain why some students follow more successful educational pathways than others.

Personality: Evidence for an association with academic achievement. A growing body of studies has investigated the role of personality traits in educational contexts. Over the last decade, several meta-analyses have shown that conscientiousness and openness have consistently accounted for differences in achievement (Hough, 1992; McAbee & Oswald, 2013; O'Connor & Paunonen, 2007; Poropat, 2009, 2014; Richardson et al., 2012; Trapmann et al., 2007). However, most of these meta-analytical studies have included only a restricted range of academic outcomes (e.g., postsecondary performance measures; for an exception, see Poropat, 2009, 2014) and have not distinguished between different measures of educational achievement and their features. In addition, with few exceptions (e.g., Meyer et al., 2019), most prior studies have focused on lower secondary school, which is surprising given the importance of achievement measures at the end of upper secondary school for postsecondary education (e.g., Brandt et al., 2019; Lechner et al., 2017; Spengler et al., 2013; Tetzner et al., 2019).

Previous research on learning and individual differences has developed a more general framework for explaining the associations between personality traits and student learning. Specifically, Zhang and Ziegler (2016) found support for the Big Five-Narrow Traits Model (B5NT). This model suggests that the associations between personality traits and performance result from two specific intermediate processes, namely, self-beliefs (e.g., self-concept) and learning approaches (e.g., deep learning vs. surface learning). These processes are referred to as narrow traits (see also Zhang & Ziegler, 2018) and are assumed to mediate the association between personality and achievement. These studies and the B5NT framework can provide a more substantial understanding of the association between student performance and personality.

Generally speaking, a substantial share of prior studies on the relations between personality traits and achievement outcomes have not controlled for relevant additional variables (e.g., students' socioeconomic background, cognitive ability, and gender). This might be especially relevant for openness, which describes individual differences in curiosity and creativity. Individuals who are open become easily excited by new experiences, are rather unconventional, and have wide interests. Out of the five broad traits, openness is the one that has the closest conceptual overlap with general cognitive ability. For instance, as outlined by Ziegler et al. (2012), there seems to be a strong, long-term relationship between openness and cognitive abilities, explicitly outlined in the Openness-Fluid-Crystallized-Intelligence (OFCI) model (see also Ziegler et al., 2018). To evaluate the incremental validity of openness with respect to academic achievement, it is necessary to statistically account for students' cognitive abilities.

Taken together, prior research on the association between personality and student performance has provided a very useful foundation for better explaining these relations (e.g., Poropat, 2009; Zhang & Ziegler, 2016, 2018). However, up to now, most models and studies have used a fairly broad definition of “performance” and did not consider features of

achievement measures when investigating the (differential) associations of personality traits with different achievement measures.

The Personality-Achievement Saturation Hypothesis (PASH): Predictions. The five features of achievement measures described above provide a way to identify and categorize similarities and differences between seemingly similar achievement measures. This ability to make distinctions is the prerequisite for the second part of the PASH, in which the specific associations between personality and achievement are proposed and which we will describe next. To determine these, we also considered prior findings and existing models and thus decided to focus on conscientiousness and openness as these are the traits that were found in prior research (e.g., Brandt et al., 2019; Lechner et al., 2017; Poropat, 2014; Spengler et al., 2013; Tetzner et al., 2019) to be the most meaningful traits for explaining associations between personality and achievement.

Conscientiousness. Regarding standardization, the PASH would suggest that if the level of standardization is low, the impact of a teacher's subjective decisions on evaluations of students' performance should be high. This is typically the case for course grades, as they are strongly based on teacher-developed course-specific exams. Teachers also assess social interactions in class, for instance, whether students are putting forth effort, working hard, and working persistently—all of which reflect aspects of personality (Roberts et al., 2014). Students who are more conscientious will find it easier to fulfill the requirements in the classroom, for instance, in terms of preparing for teacher-assigned tests, doing homework, and actively engaging in class, all of which are relevant for teachers' evaluations of students (Gray & Watson, 2002). Therefore, in line with prior research, the PASH suggests that conscientiousness is likely to be more closely related to measures that are low on standardization, as is typical of course grades or GPA (e.g., Brandt et al., 2019; Lechner et al., 2017; Lüdtke et al., 2004; Nofle & Robins, 2007; Spengler et al., 2013). The PASH also suggests that if teachers' personal preferences have less influence on the evaluation process,

the role of conscientiousness should decrease as conscientiousness-related behaviors that students show in class (e.g., doing homework, actively engaging in class) are not as relevant for highly standardized achievement measures compared with achievement measures with low standardization. Regarding relevance, the PASH would suggest that students who are high on conscientiousness will be better prepared for achievement-measure-relevant tasks (e.g., written course assignments) when the relevance of the resulting measure is higher. In the same vein, conscientious behavior should be less strongly associated with outcomes when curricular validity and instructional sensitivity are lower because the overlap between “What gets tested?” and “What was learned and how was it learned in class?” is reduced.

Openness. The PASH also suggests that students scoring higher on openness should earn higher grades but that openness should be particularly relevant when working with unknown, new testing formats (i.e., with low instructional sensitivity or low curricular validity). This results from the fact that open students use learning strategies more intensively (Blickle, 1996), and this becomes more relevant when students must solve unknown tasks. In addition, open students have more interest in exploring challenging tasks (i.e., tasks that are high in cognitive ability saturation), are described as more flexible in their thinking, and are open to developing new ideas and investigating (Digman, 1990). From this perspective, openness should be more strongly associated with less relevant but new and unknown achievement measures (e.g., standardized tests as operationalized in this study) because such measures provoke a desire to explore and investigate. Finally, when an achievement measure depends less on subjective teacher judgments, openness should have a stronger influence on how students score on this measure.

The importance of openness when working on new tasks can be exemplified by using the well-established Cattell-Horn-Carroll (CHC) model (Schneider & McGrew, 2012). According to McGrew (2009), this model distinguishes between two main factors: fluid intelligence (Gf) and crystallized intelligence (Gc). Combined with assumptions about the

different achievement measures and their features, as proposed by the PASH, these models would suggest that with decreasing instructional sensitivity and curricular validity, the measures should typically increase more in their cognitive ability saturation, and Gf (here expressed via openness) should play a larger role because task formats are less well-known and require more operations related to novel problem solving, which is inherent to Gf. The OFCI (oriented on the Environmental Success hypothesis) suggests that more open people should score higher on Gf because they use learning opportunities more often, both inside and outside the classroom.

Prior empirical evidence for the PASH. Although prior studies were not tailored to test the PASH's predictions, a number of previous empirical results have been in line with this hypothesis. For instance, in a representative sample of 15-year-old students ($N = 898$) and another heterogeneous sample of over 2,000 students in Grades 9 or 10 from Luxembourg, Spengler, Lüdtke, Martin, and Brunner (2013) demonstrated that conscientiousness was more closely related to course grades (low standardization, moderate to high relevance, high curricular validity, high instructional sensitivity, moderate cognitive ability saturation). Openness had the strongest association with achievement test scores (high standardization, low relevance, low curricular validity, low instructional sensitivity, high cognitive ability saturation) even after general cognitive abilities were controlled for. The differential predictive power of personality traits was also found for university students (Nofle & Robins, 2007): Openness was mainly associated with SAT scores (high standardization, high relevance, low to moderate curricular validity, low instructional sensitivity, high cognitive ability saturation), whereas grade point average (GPA; rather low standardization, high relevance, high curricular validity, high instructional sensitivity, moderate to high cognitive ability saturation) was primarily predicted by conscientiousness. This pattern of results was also found in other studies (Brandt et al., 2019; Israel et al., 2019; Lechner et al., 2017;

Lüdtke et al., 2004; Meyer et al., 2019; Rosander & Bäckström, 2014; Stankov & Lee, 2008; Tetzner et al., 2019).

The Present Study

As specified above in the personality-achievement saturation hypothesis (PASH), different main features of the achievement measures (standardization, relevance, curricular validity, and instructional sensitivity, and cognitive ability saturation) are important and should be systematically linked to the strengths of the personality-achievement association. The present study provides an in-depth test of the PASH using data from three large-scale studies from a total of about 15,000 students at the end of upper secondary school.

We aimed to address two specific research questions: To what extent are personality traits related to the different achievement measures at the end of upper secondary school (RQ1)? On the basis of the PASH, we expected that conscientiousness and openness would be statistically significantly positively related to students' grades and standardized achievement-test results at the end of upper secondary school, even after we adjusted for students' gender, family socioeconomic background (HISEI), cognitive abilities, and course level (advanced vs. basic course).

Are there differences in the predictive power of personality traits between the different achievement measures (RQ2)? On the basis of the PASH, we expected that conscientiousness would be more strongly related to all three types of grades, compared with standardized test scores, because grades have lower standardization, higher relevance, higher curricular validity, higher instructional sensitivity, and lower cognitive ability saturation. Regarding the three types of grades, the PASH suggests that conscientiousness should be most highly related to GPA and course grades, followed by final examination grades, mainly due to increasing standardization and decreasing instructional sensitivity. In addition, the PASH implies that openness should be especially predictive of measures that are highly standardized, less relevant, less curriculum-valid, less instructionally sensitive, and high on cognitive ability

saturation (e.g., Lüdtke et al., 2004; Nofle & Robins, 2007). As outlined above, this study focuses on explaining how achievement measures are associated with conscientiousness and openness, as these personality traits have been found to be most relevant for achievement in prior studies. Associations with the other Big Five traits are explored as well. Note that we estimated unadjusted models (without controlling for covariates) and adjusted models (controlling for covariates and cognitive ability saturation as measured with a cognitive ability test) to provide the most detailed insights into patterns of differential associations.

Method

Ethics Statement

The ministry of education and cultural affairs of the state of Baden-Württemberg (where the different waves of the TOSCA study were conducted) reviewed the school assessments used in this study (TOSCA 2002 and TOSCA 2006). Back then, the ministry took sole responsibility for reviewing research ethics/privacy issues in all state-wide research studies that took place in schools. Regarding the third data set we used (TOSCA LAU 2005), the Ministry of Schools and Vocational Training of the Free and Hanseatic City of Hamburg took responsibility for reviewing research ethics and privacy issues.

Sample

In this study, we considered a large set of students at the end of upper secondary school from three large-scale studies. Among other arguments that apply to conducting a meta-analysis even with small numbers of studies (e.g., Goh et al., 2016), we considered the data from these three studies to increase the generalizability of our findings across states and upper secondary school course systems. We analyzed data from $N = 4,682$ students (54.0% women; age: $M = 19.56$ years, $SD = 0.79$) from the TOSCA 2002 study (Köller et al., 2004; Trautwein et al., 2010). The data set consisted of students from 149 schools from the German state of Baden-Württemberg. Students were in their final year of upper secondary school. From the TOSCA LAU study (Trautwein et al., 2007), we considered data from a total of $N =$

5,280 students from 108 upper secondary schools in Hamburg (54% women; age: $M = 19.65$ years, $SD = 0.96$). Finally, we used data from $N = 4,943$ upper secondary school students from 156 schools from the TOSCA 2006 study (Trautwein et al., 2010). The majority of schools were the same schools as assessed in TOSCA 2002 ($N = 146$), from the German state of Baden-Württemberg but 4 years later (55.5% women; age: $M = 19.44$ years, $SD = 0.68$).

Instruments

Course grades. In all three studies (i.e., TOSCA 2002, TOSCA LAU, and TOSCA 2006), we assessed three different types of grades: course grades, final examination grades, and GPA. First, all studies provided course grade information based on official report cards from the first semester of the final school year (Grade 13, Semester 1: Grade 13.1) in English and mathematics. Course grades were based on oral participation in the course and written examinations that had been prepared by the individual teachers. Each of these grades counted for about 1.3% to 1.7% (basic course) or about 2.7% to 3.5% (advanced course) of GPA. Course grades are based on individual evaluations by students' course teachers and do not count as much toward (weighted) GPA scores. They can therefore be considered less standardized, moderately to highly relevant, highly curriculum-valid, highly instructionally sensitive, and moderately saturated with cognitive ability (see Table 1). Course grades ranged from 0 points (*worst grade*) to 15 points (*best grade*).

Final examination grades. All data sets provided official report card information on grades in final secondary-school examinations in mathematics and English. Unlike grades from the first semester of the final school year, grades from final secondary-school examinations were based on curriculum-oriented, centrally administered, state-wide exams (*Zentralabitur*). In addition to the evaluation of the exam by the course teacher, they were also evaluated by one external teacher to ensure objectivity. These exams were high-stakes in the sense that they counted more toward the final examination grade (GPA; about 6.6% to 8.3%), which builds the foundation for university access to specific subjects. Final

examination grades, as operationalized in our study, are based on statewide curriculum-valid examinations, which are evaluated by (at least) two teachers on the basis of a common protocol, and they count more heavily toward students' final GPA. These grades can thus be considered highly standardized, highly relevant for students, and highly curriculum-valid (see Table 1). However, as this examination is centrally administered and developed without input from the students' teachers, the contents of this examination differ from what students have been working on in class. Therefore, its instructional sensitivity typically ranges from low to moderate, whereas the influence of general cognitive abilities varies from moderate to high. Again, these grades ranged from 0 points (*worst achievement*) to 15 points (*best achievement*).

GPA. We also considered students' GPA, which was measured on a scale ranging from 1.0 (*best-possible achievement*) to 4.0 (*worst achievement that is not yet failing*). Information about GPA was based on official report cards. In all states, GPA can be understood as a weighted average of a specific number of course grades from Grades 12 and 13 and final examination grades (see Hübner et al., 2017, for more information). These grades result from a set of subjects that typically vary across students because students do not all enroll in similar subjects on the same level (e.g., advanced vs. basic courses). To be able to ensure that GPA would be comparable to the other achievement outcomes, we reverse-coded GPA so that a higher GPA indicated better achievement, whereas a lower GPA indicated worse achievement. It is important to recognize that GPA consists of many different grades (typically 40 course grades and final examination grades, weighted to count as a total of 20 courses), each of which contributes only a small share to the final GPA score. GPA was therefore rated as "rather low" on standardization because this measure is a weighted GPA score, which consists of poorly standardized course grades, which comprise two thirds of the GPA score, and highly standardized final examination grades, which comprise one third of the GPA score. The relevance of each of these individual grades varies from moderate to

high, which is why we defined the relevance of GPA as moderate to high in the following.

Taken together, GPA is therefore rather low on standardization, has a high relevance for students, is highly curriculum-valid, has a high instructional sensitivity, and has a moderate to high cognitive ability saturation.

Standardized achievement tests. To test students' mathematics achievement, all three studies made use of an advanced mathematics test that was based on items from the Third International Mathematics and Science Study (TIMSS; Mullis et al., 1998). Mullis et al. (1998) reported that the advanced mathematics test assesses "current thinking and priorities in the field of mathematics" (p. 284). Overall, 68 items from the fields of (a) Numbers, Equations, and Functions, (b) Analysis, (c) Geometry, (d) Propositional Logic and Proofs, and (e) Probability and Statistics were administered. About two thirds of all items were multiple-choice questions. The remaining items were administered as open format items. For the current analysis, we used weighted likelihood estimators (WLEs; Warm, 1989), which resulted from IRT scaling, using a generalized partial credit model (TOSCA 2002: Rel. = .72; TOSCA LAU: Rel. = .64; TOSCA 2006: Rel. = .68). The standardized achievement test in mathematics was built using (curriculum-valid) TIMSS items. The test score is therefore highly standardized, has no relevance for the student, is curriculum-valid, has a low instructional sensitivity, and has a high cognitive ability saturation (see Trautwein et al., 2010, for further information on the curricular validity of the test items).

Furthermore, a short version of the Test of English as a Foreign Language (TOEFL) was used to assess students' English competencies. The test consists of 79 items that form three subscales: Listening and Comprehension (28 items; TOSCA 2002: Cronbach's α = .79; TOSCA LAU: Cronbach's α = .85; TOSCA 2006: Cronbach's α = .79), Structure and Writing Expression (23 items; TOSCA 2002: Cronbach's α = .75; TOSCA LAU: Cronbach's α = .83; TOSCA 2006: Cronbach's α = .75), and Vocabulary and Reading Comprehension (28 items; TOSCA 2002: Cronbach's α = .77; TOSCA LAU: Cronbach's α = .84; TOSCA 2006:

Cronbach's $\alpha = .77$). Overall, the internal consistency of the TOEFL was high (TOSCA 2002: Cronbach's $\alpha = .90$; TOSCA LAU: Cronbach's $\alpha = .93$; TOSCA 2006: Cronbach's $\alpha = .90$). The TOEFL test is highly standardized, but because the students did not know they were working on TOEFL items and did not get a TOEFL certificate afterwards, the test scores were not relevant for them. In addition, TOEFL items are not explicitly linked to students' curricula or classroom instruction, but they have a high cognitive ability saturation (see Table 1).

Personality traits. In TOSCA 2002 and TOSCA 2006, personality was measured with the German version of the NEO-FFI (Borkenau & Ostendorf, 1993). Each trait was assessed with 12 items. In both studies, items were rated on a 4-point rating scale (Lüdtke et al., 2004), ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). For all scales, the internal consistency (Cronbach's α) was adequate (TOSCA 2002: Conscientiousness: .83, neuroticism: .81, extraversion: .77, openness: .73, agreeableness: .73; TOSCA 2006: Conscientiousness: .84, neuroticism: .81, extraversion: .77, openness: .70, agreeableness: .75).

In TOSCA LAU, personality was measured with the German version (Lang et al., 2001) of the Big Five Inventory (BFI; John et al., 1991). The items were rated on a 5-point rating scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The internal consistency of the five traits was adequate (Conscientiousness: .80, neuroticism: .78, extraversion: .88, openness: .79, agreeableness: .68).

Covariates. Course level. In both subjects, mathematics and English, students were able to self-select into advanced or basic courses. Whereas advanced courses took about five hours per week, basic courses in mathematics and English were taught for about three hours per week. This course choice was done at the beginning of the final 2 years of upper secondary school and could not be changed afterwards. In the student cohort assessed in TOSCA 2006, course choice was abandoned in favor of core courses on an advanced course level in mathematics and a foreign language (typically English). Compared with the TOSCA 2002 and TOSCA LAU data sets, students in the TOSCA 2006 study were not able to choose

between an advanced or basic course, due to a reform of upper secondary school in 2002 (Hübner et al., 2017; Trautwein et al., 2010). Instead, all students were required to take an advanced mathematics course and choose one foreign language (typically English) on an advanced course level.

Socioeconomic background. We used information about the highest occupation in the family (of either the father or the mother) to measure socioeconomic background (based on parent and student information). Occupational codes were based on the International Standard Classification of Occupation (ISCO-88). ISCO values were transformed into International Socioeconomic Index of Occupational Status (ISEI) 88 scores (Ganzeboom & Treiman, 1996) for which higher scores indicate higher socioeconomic background.

General cognitive ability. General cognitive ability was assessed with the subscales Figure Analogies and Verbal Analogies from the German version of the Cognitive Ability Test 4-12 + R (Heller & Perleth, 2000). The figural subscale consists of 25 items, and the verbal subscale consists of 20 items, which were administered in a multiple-choice format. In a subsequent analysis, we used a 2-parameter logistic model (Birnbaum, 1968) to simultaneously estimate a composite weighted likelihood estimator (Warm, 1989) for the two subscales (e.g., Vock et al., 2013). The reliability of the score was good (TOSCA 2002: WLE reliability = .77; TOSCA LAU: WLE reliability = .64, TOSCA 2006: WLE reliability = .78).

Students' gender. The models with covariates also contained students' gender, which was coded as 0 (*male*) and 1 (*female*).

Statistical Analysis

To test the associations between the personality traits and the different achievement measures, we specified a series of multivariate multiple regression models separately for each of the three data sets. In more detail, we specified two models in each data set for each domain (i.e., English and mathematics) including all of the four achievement measures (i.e., course grades, GPA, final examination grades, and standardized achievement-test scores) as

outcomes. In the first model, we predicted achievement outcomes with the Big Five personality traits: conscientiousness, neuroticism, extraversion, openness, and agreeableness (Model I). In the second model, covariates were included in addition to the personality traits, specifically students' gender, family socioeconomic background (HISEI), cognitive abilities, and course level (Model II). We created models that included these covariates to control for their potential to confound the associations between personality and achievement outcomes. In order to compare the effects of the personality traits on the different achievement tests, we present 95% confidence intervals in Figure 1 and formally test for differences between the regression coefficients for the Big Five predictors of the four outcomes using the model constraint option implemented in Mplus. In a final step, we aggregated the results of the three data sets using meta-analytic fixed effects models with inverse-variance weights (Borenstein et al., 2010; Viechtbauer, 2010). These aggregates can be interpreted as the average outcome of the association across the three studies. A variety of arguments have been outlined in the literature for why aggregating results across (even a few) different studies can be advantageous. Among others, these arguments include replicability, embracing inconsistencies across studies, and increasing the precision of estimates (e.g., Goh et al., 2016). Separate results for the three single studies can be found in the supplemental material (Appendix A).

We only considered data from students in advanced or basic courses in the TOSCA 2002 and TOSCA LAU studies because no grading information existed for students who deselected a subject. All students had to choose mathematics as an advanced course or as a basic course; therefore, student deselection had to be considered only for grades in English. Due to deselection in English, the samples varied slightly between mathematics and English. We therefore considered GPA separately for all students and those who chose English as a basic or advanced course. In TOSCA 2006, students were tested after a general reform of upper secondary school, which introduced mandatory course enrollment in German,

mathematics, and one foreign language (typically English). Furthermore, the reform also implemented obligatory enrollment in one foreign language course on an advanced level (Trautwein et al., 2010). Although students could opt out of English as a foreign language, the majority of students participated in English core courses (90.24%; see Jonkmann et al., 2010). In line with the TOSCA 2002 and TOSCA LAU analyses and besides GPA, where we considered all students, in subsequent analyses, we did not include students who did not participate in English as a core course because they most likely differed from the other students, potentially leading to a selection bias.

Inspection and preparation of the data was done in R (R Development Core Team, 2019). Item response models were specified using the TAM package (Kiefer et al., 2017). For competence tests, we used Warm's weighted likelihood estimator (WLE; Warm, 1989) as a person parameter estimate. The final data sets were transferred to Mplus 8.2 (Muthén & Muthén, 1998-2017) using the mplusautomation package in R (Hallquist & Wiley, 2018). Estimation of meta-analytic fixed effects models was done using the metafor package in R (Viechtbauer, 2010). We decided to use a fixed effects model when aggregating the results of the different studies so that we could estimate an average effect across the three data sets. The results tables provide the fully standardized estimates, where the dependent and independent variables were standardized within studies before the analyses.

Robustness checks. We also conducted some additional analyses to control for measurement error in the Big Five personality traits. To do so, we utilized a single indicator approach (e.g., Hoyle, 2012), whereby the residual variance of personality scores is fixed to $(1 - \text{reliability}) * \text{sample variance}$. The results suggested that the average differences between the beta coefficients of the personality traits in the original analysis and those based on the single indicator approach were small and did not yield differences in the interpretation of the results: $\Delta_{\text{TOSCA 2002}}: .01$, $\Delta_{\text{TOSCA LAU}}: .01$, and $\Delta_{\text{TOSCA 2006}}: .01$.

Clustered data structure. Students from the same schools are more similar to each other than they are to students from other schools. This structure needs to be considered in the statistical model to avoid a potentially biased estimation of standard errors (Snijders & Bosker, 2012). We considered the clustered structure of the data by using a design-based correction of standard errors. The use of a design-based correction is recommended when the cluster level is not critical to the focal research question, as it draws on fewer assumptions than random effects models do (McNeish et al., 2017).

Missing values. In the current data set, the percentage of missing values on the dependent variables was below 5%. We decided to use full information maximum likelihood (FIML) estimation to account for missing values, and we considered covariates from the full model as auxiliary variables in the models without covariates (Enders, 2010; Graham, 2009).

Results

In the following, we focus on the aggregated results of the three studies. Individual results for each of the three studies are provided in the supplemental material (Tables S1 to S6). After the preliminary results, which include aggregated correlation coefficients, we addressed RQ1 on the association between personality traits and the three different achievement measures, as predicted by the PASH, separately for mathematics and English. Subsequently, we examined the association between personality traits and GPA. Finally, we tested for differences in the predictive power of the personality traits across the different achievement measures (RQ2).

Preliminary Analyses

First, we inspected the descriptive statistics for the different variables in TOSCA 2002, TOSCA LAU, and TOSCA 2006. The results are reported in Table 2. Table 3 provides the meta-analytically aggregated correlation coefficients: Conscientiousness was positively related to all grades (ranging from $r = .08$ to $.24$, ps ranging from $p < .001$ to $p = .006$). Furthermore, the association between conscientiousness and standardized achievement-test

scores in mathematics and English was descriptively smaller than for grades (ranging from $r = -.06$ to $.06$, all $ps < .001$). Openness was statistically significantly positively related to all grades and test scores (ranging from $r = .03$ to $.24$, ps ranging from $p < .001$ to $p = .024$) except advanced ($r = .02$, $p = .347$) and basic ($r = -.03$, $p = .098$) mathematics course grades. After these preliminary analyses, we investigated RQ1 regarding the association of personality traits with the different achievement measures and RQ2 regarding the differential predictive power of personality traits across different achievement measures.

The Association of Mathematics and English Achievement with Personality Traits (RQ1)

Regarding RQ1, on the basis of the PASH, we expected that conscientiousness and openness would be statistically significantly positively associated with students' grades and standardized achievement-test results at the end of upper secondary school even after controlling for the covariates. The aggregated results regarding the associations between the personality traits and the different achievement measures in mathematics are shown in Table 4 (see Table 8 for an overview of all results). Figure 1 shows the aggregated results for mathematics and English, separately for the four different outcome measures and the different personality traits, after controlling for the potential confounding influences of the covariates (Model II).

In line with our expectations, we found a positive association between conscientiousness and course grades ($\beta = .24$, $p < .001$) after controlling for the other personality traits and covariates in the model. Students who scored higher on conscientiousness had statistically significantly higher grades. In addition, openness was weakly negatively related to course grades ($\beta = -.03$, $p = .016$).

Regarding final examination grades, we found a statistically significant positive association for conscientiousness ($\beta = .17$, $p < .001$; see Table 4). The coefficient for openness was positive and statistically significant in the unadjusted model ($\beta = .04$, $p = .003$), but it was

no longer statistically significant after general cognitive abilities and the other covariates were added to the model ($\beta = .02, p = .137$).

Next, we investigated the association between personality traits and standardized achievement-test scores. As can be seen in Table 4, we found a statistically significant regression coefficient for conscientiousness ($\beta = .06, p < .001$). Furthermore, openness was positively related to standardized achievement-test scores ($\beta = .07, p < .001$).

The results for English revealed a statistically significant positive association between conscientiousness and course grades ($\beta = .14, p < .001$; see Table 5). In line with our hypothesis, we also found a positive regression coefficient for openness ($\beta = .16, p < .001$).

Regarding final examination grades, we found a comparable picture. First, there was a positive association with conscientiousness ($\beta = .10, p < .001$), underscoring the positive association between conscientiousness and final examination grades also found in mathematics. Next, there was a positive coefficient for openness ($\beta = .15, p < .001$).

When predicting standardized achievement-test scores in English, we found that openness was positively associated with standardized test performance ($\beta = .20, p < .001$). Most interestingly, conscientiousness did not turn out to be statistically significantly related to standardized test scores ($\beta = -.01, p = .289$).

When comparing the bivariate correlations and the results from the multiple regression coefficients, our results suggested suppression effects for some variables in some models. From a more general perspective, suppressor variables can be seen as helpful because they boost the predictive power of the other variables in the model. However, they might also complicate the interpretation of findings (e.g., Watson et al., 2013). In our case, we found evidence for at least two types of suppression, namely, classical suppression and cooperative suppression. The first seemed to result from zero to very small associations between neuroticism and achievement outcomes but substantial (negative) associations between neuroticism and conscientiousness ($r = .25, p < .001$). The latter seemed to result from small

negative associations between openness and conscientiousness ($r = -.04, p < .001$) but positive associations between both of these personality traits and the achievement outcomes. Suppressor variables have been repeatedly discussed in the literature. However, up to now, no common method for how to treat them has been established (Watson et al., 2013). Although they seemed to be zero or very small in most cases, we generally caution readers to carefully consider them when interpreting the individual results.

Associations between GPA and Personality Traits (RQ1)

Next, we took a closer look at the association between personality and GPA. When considering all students (see Table 6), we found a positive association for conscientiousness ($\beta = .25, p < .001$) as well as a substantial positive association for openness ($\beta = .17, p < .001$). We found very similar results when considering the subset of students who selected English as an advanced or basic course (see Table 6).

Summary of Findings for RQ1

As can be seen in Table 8, for RQ1, we found strong support for our hypotheses, which were based on the PASH, with few exceptions. In sum, 13 of the 16 associations between the achievement measures and openness/conscientiousness were statistically significantly positive in the adjusted models. Exceptions were associations between standardized achievement-test scores in English and conscientiousness ($\beta = -.01, p = .289$), and openness' associations with course grades ($\beta = -.03, p = .016$) and final examination grades in mathematics ($\beta = .02, p = .137$). When more closely inspecting the R^2 values from the different regression models, we found that the Big Five personality traits seemed to predict the different achievement measures to the same extent. Overall, they contributed 4% to 8% to the variance that was explained in course grades, final examination grades, and standardized test achievement. The variance that was explained in GPA was slightly higher and ranged from 10% in mathematics to 11% in English. The slightly higher R^2 for GPA was

also mirrored by the individual partial regression coefficients (see Table 6). Here, particularly conscientiousness and openness seemed to contribute to explaining GPA.

Differential Associations of Achievement Measures in Mathematics and English with Personality Traits (RQ2)

In order to more closely investigate the PASH, we compared the predictive power of personality traits across the different achievement measures using meta-analytic summaries of results of multivariate regression models (see Table 7). We expected that, in particular, conscientiousness would play a role when standardization was lower and instructional sensitivity was higher such as for course grades or GPA. Regarding the three types of grades, the PASH suggests that conscientiousness should be most strongly related to GPA and course grades, followed by final examination grades due to increasing standardization and decreasing instructional sensitivity. Openness was expected to be more strongly related to achievement measures that had lower relevance as well as lower curricular validity and instructional sensitivity but a high cognitive ability saturation.

In line with our predictions, we found that conscientiousness was substantially more strongly related to course grades ($\Delta\beta = .17, p < .001$), final examination grades ($\Delta\beta = .10, p < .001$), and GPA ($\Delta\beta = .18, p < .001$) than with standardized test scores. Furthermore, in line with our hypothesis, conscientiousness was more strongly related to course grades and GPA than with final examination grades (both $\Delta\beta s = .07, ps < .001$), where standardization was higher. In addition, openness was statistically significantly more strongly related to standardized test scores compared with course grades ($\Delta\beta = -.09, p < .001$) and final examination grades ($\Delta\beta = -.05, p < .001$). Interestingly, contrary to our expectations, openness was more strongly positively associated with GPA than with standardized achievement-test scores ($\Delta\beta = .10, p < .001$).

Similar to mathematics, in English, we found that conscientiousness was more strongly associated with course grades than with standardized achievement-test scores ($\Delta\beta =$

.15, $p < .001$; see Table 7). In addition and in line with our expectations, the regression coefficient for conscientiousness was statistically significantly larger when predicting final examination grades than when predicting standardized test scores ($\Delta\beta = .11$, $p < .001$). Further, conscientiousness was more strongly related to course grades versus final examination grades ($\Delta\beta = .04$, $p = .002$). Finally, in line with our assumptions that were based on the PASH, we found that openness was statistically significantly more predictive of standardized test scores than it was of final examination grades ($\Delta\beta = -.05$, $p < .001$), course grades ($\Delta\beta = -.04$, $p = .001$), or GPA ($\Delta\beta = -.04$, $p < .001$).

Summary of Findings for RQ2

In sum, all eight associations with conscientiousness were in line with our predictions, with the exception of standardized test scores, which were found to be most strongly positively associated with openness in English (all $ps \leq .001$). However, besides a positive association between standardized test scores and openness in mathematics, here, GPA was considerably more strongly associated with openness ($\beta = .17$, $p < .001$ vs. $\beta = .07$, $p < .001$; $\Delta\beta = .10$, $p < .001$).

Discussion

With this study, we introduced the PASH, a novel hypothesis about the associations between personality and achievement measures and analyzed the associations between personality and achievement measures with different features (standardization, relevance, curricular validity, instructional sensitivity, and cognitive ability saturation) in three large-scale data sets containing data from students at the end of upper secondary school. We aimed to answer two major research questions: First, we wanted to know the extent to which personality traits were related to the different outcomes at the end of upper secondary school, after controlling for additional covariates. Second, we explored whether there were differences in the predictive power of personality traits for the four different achievement outcomes, as suggested by the PASH.

The results, which were largely in line with expectations based on the PASH, suggest that personality traits can explain variance in students' achievement but that the associations between achievement measures and personality traits vary, depending on the features of the measure in use. For instance, as shown for our results in English (see Tables 4 to 7), measures with a lower level of standardization were more strongly positively associated with conscientiousness. Specifically, conscientiousness had the strongest association with GPA, followed by course grades, final examination grades, and standardized test scores, the last of which was essentially zero. According to our conceptual framework (see Table 1), we argue that this results in particular from a decreasing standardization and increasing curricular validity and instructional sensitivity. Furthermore, openness was more strongly associated with test scores when compared with grades in five out of six cases (see Table 8). One exception was GPA: When considering the whole sample, openness was more strongly associated with GPA than it was with standardized achievement-test scores. For English, associations between the other achievement measures and openness were substantially higher and in line with our assumptions that were based on the PASH.

The Importance of Considering Features of Achievement Measures

This study provides an important extension to previous research: It merges research from the fields of educational psychology and personality psychology by providing a conceptual framework of features of achievement measures in order to improve the understanding of personality-achievement saturation. Our study suggests that different achievement measures indeed have different associations with personality, and it seems worthwhile to conceptualize achievement measures in more detail with respect to their main features (standardization, relevance for the student, curricular validity, instructional sensitivity, and cognitive ability saturation). We carefully derived and defined these features by considering a wide range of prior research (e.g., Au, 2007; Borghans et al., 2016; Cole & Osterlind, 2008; Koretz, 2008; McClung, 1979; Polikoff, 2010). As outlined, a dichotomous

perspective involving only grades versus standardized tests is far from being universally applicable or adequate (e.g., Bowers, 2011; Brookhart et al., 2016). Grades and test scores differ greatly in their features across countries, and the positioning of achievement measures along the more fine-grained main features (e.g., standardization, relevance, curricular validity) can help to overcome the limitations that come with blurry dichotomous conceptualizations. This is also important for overcoming the difficulties that have been encountered in trying to develop an intercultural understanding resulting from the unclear labeling of different achievement measures as either grades or standardized tests. In addition, this might help provide a better understanding of the (predictive) validity of different types of achievement measures (e.g., Kuncel et al., 2001; Kuncel et al., 2005). Taken together, the PASH helps to provide more sophisticated explanations for specific findings from past and future research, especially for outcomes at the end of upper secondary school, where grades and standardized tests have an important impact on transition decisions and selection processes.

Associations of Personality and Achievement Measures

In line with the PASH and previous research, we found that conscientiousness was more strongly associated with all types of grades than it was with standardized achievement-test scores, whereas openness was more strongly related to standardized achievement-test scores (see Lüdtke et al., 2004; Nofle & Robins, 2007; Spengler et al., 2013). Interestingly, as suggested by the PASH, we found differences between the strength of the association between grades and conscientiousness. Conscientiousness was most strongly associated with GPA and course grades, followed by final examination grades (see Table 8). On the basis of the PASH, we argue that this finding results from the different features of achievement measures: Teacher-assigned course grades are mostly built on assessments of students' verbal participation in the classroom and their performance in a number of tailor-made exams. These assessments are strongly oriented on the curriculum (curricular validity), and teachers

typically test students on the content they have taught in a similar manner in their regular lectures (instructional sensitivity). There are many materials that can be used to prepare for such classroom assessments (e.g., the textbook used by the teacher, previous homework assignments). Therefore, students scoring high on conscientiousness are likely to use these materials more often, to more thoroughly prepare their homework and written examinations, and related to this, to have a better foundation to engage in the classroom in a reasonable manner. Moreover, students with high levels of conscientiousness may be more dedicated to working on assignments in school and may be more disciplined when doing their work (see Spengler et al., 2013). In addition, teachers can observe this socially relevant behavior and also use it as an indicator for grading. Overall, this behavior leads to better preparation for less standardized, highly curriculum-valid, and highly instructionally sensitive assessments.

This explanation of our findings is also supported by the differences in the predictive powers of the three types of grades. Course grades are to a large extent based on exams by the course teacher, which are highly instructionally sensitive (i.e., the teacher typically tests what he/she has taught in class). Final examination grades are based on centrally developed exams, which are also highly curriculum-valid but more standardized and less instructionally sensitive. These types of grades are therefore based on content that naturally has a reduced overlap with what was actually taught in the classroom, and students cannot prepare for them as easily. As the evaluation procedure of final examination grades is highly standardized, teachers' perceptions of students have less influence on these types of grades. Therefore, conscientiousness is less strongly associated with such measures.

In the same vein, we expected that openness would be particularly relevant to performances on standardized achievement tests. Our results largely supported this expectation. We found that students who scored higher on openness showed a high standardized test performance, even after we controlled for the other personality traits, cognitive abilities, socioeconomic background, and gender. This might be seen as surprising

because standardized achievement tests are traditionally considered to be “more objective,” suggesting that these measures mostly depend on factors that are related to student knowledge and cognitive abilities (Borghans et al., 2016). On the basis of our findings, particularly when the relevance, curricular validity, and instructional sensitivity of achievement measures are lower (e.g., in English), openness can be assumed to be more closely related to academic achievement because open students use learning strategies more intensively. These learning strategies are in turn related to better performance on tests (Blickle, 1996). Moreover, openness is the only personality trait that is related to intelligence, which in turn is more closely related to achievement test scores than it is to grades. Whereas intelligence refers to students’ cognitive abilities, openness refers to students’ interest in and willingness to explore new tasks. In this regard, openness might also capture aspects of cognitive ability that are not reliably/validly measured with cognitive ability tests. Overall, the notion that presumably more objective standardized achievement tests are generally less “flawed” or less influenced by factors that are not related to students’ cognitive abilities in comparison with grades, which are strongly influenced by such factors, did not hold for any personality traits in either subject (Bowers, 2011; Brookhart et al., 2016; Casillas et al., 2012; Koretz, 2002). Particularly in English, openness explained substantial amounts of variance in test achievement, whereas the association in mathematics was much smaller. To some extent, these findings reflect the domain-specificity of the influence of personality. Openness might actually reflect a verbal and not a numerical orientation (e.g., Marsh et al., 2006). This would be in line with previous findings that showed an association between openness and verbal SAT scores in a college sample (Nofle & Robins, 2007).

Practical Implications

Surprisingly, although previous research has already underscored the impact of student characteristics on achievement measures (Casillas et al., 2012), policy and practice have barely discussed the meaning of these findings for their individual plans of action.

For instance, when selecting students or employees, the positive associations between the achievement measures and conscientiousness might be a useful feature because universities and employers might on average “automatically” choose students who also score higher on conscientiousness when they consider students’ GPA, grades, or test scores. Attainment measures are therefore not “flawed” per se in one or the other way. However, our results call for a narrower consideration of these associations and for greater reflection on the findings because a large amount of variability between achievement measures seems to be explained by personality.

For the discussion about the use of standardized tests over grades, our results suggest the need to more closely consider the features of the achievement measures that are being used. For instance, if students need to score high on openness to qualify for a certain program, our results suggest that a standardized measure of English achievement should be used, as this was found to be strongly related to openness. To select more conscientious students, grades (e.g., course grades) in mathematics might be a more helpful criterion than standardized achievement tests in mathematics. Knowing what is in an achievement measure is therefore key to knowing what the population that gets selected by the specific measure will look like.

Strengths and Limitations

The results of the present study were built on extensive large-scale data sets that included almost 15,000 students at the end of upper secondary school from different German states. In order to ease the interpretation of the findings, we made use of meta-analytic fixed effects models to aggregate the results. Until now, few studies have systematically investigated students at this age, right before the transition to postsecondary education using such an extensive data set. In addition, to our knowledge, no previous study has ever investigated the predictive power of personality traits for different achievement measures using a conceptual framework such as the PASH, which emphasizes the features of these measures, and tested its predictions. Therefore, a core strength of this paper is clearly the

extensive framework of the study, which can help to more thoroughly explain past and future findings on differential associations between students' achievement and personality traits.

As in most studies, not all potentially relevant and theoretically interesting measures were assessed in our study: The standardized achievement tests in use were low-stakes tests, and it might have been particularly interesting to examine associations between high-stakes tests (high relevance) and personality traits. Therefore, our findings might be more generalizable to situations in which low-stakes tests are used frequently, such as in educational monitoring and governance (e.g., the National Assessment of Educational Progress [NAEP] study in the US or PISA). Such tests are typically used for major decisions about educational policy and governance to improve education systems (e.g., Organisation for Economic Co-operation and Development [OECD], 2015; Volante, 2016). Previous research has investigated the impact of test-taking motivation on performance on low-stakes tests and found that motivation was not statistically significantly related to test results, had no practical significance, or was generally high even for low-stakes tests (e.g., Baumert & Demmrich, 2001; Eklöf, 2007; Hopfenbeck & Kjærnsli, 2016; Penk et al., 2014). Although these findings might suggest that our findings are generalizable to some extent, perhaps even beyond low-stakes testing situations, such an idea needs to be examined more closely in the context of the PASH in future studies.

Generalizability of evidence is always a critical issue when interpreting the results of empirical studies. In this study, it is important to note that the categorization of different achievement measures along the five dimensions that were proposed by the PASH framework should be generalizable to other educational environments and achievement measures. This is explicitly shown in Table 1, where we considered other (more internationally relevant) achievement measures (e.g., SAT, AP tests) and categorized them along the same five features. The major advantage of our operationalization of the PASH clearly lies in the fact that it allows researchers to derive testable assumptions about associations between

achievement measures and personality traits, depending on the features of the different achievement measures. Again, it is important to keep in mind that our operationalization of the PASH provides only one plausible option for testing its predictions, and this of course comes with specific limitations. The categorization, for instance, was based on the result of an extensive literature review on the different achievement measures and a validation process that involved communication with experts. This process therefore relies on subjective assumptions rather than objective results from formal empirical studies. As outlined below, we provide some guidance on how future studies can more objectively derive some of the different achievement features (e.g., by investigating the degree of instructional sensitivity using longitudinal multilevel IRT models; e.g., Naumann et al., 2016).

Finally, it is important to note that the NEO FFI is an unbalanced short form of the revised NEO Personality Inventory (PI-R), meaning that it covers only a subset of the facets of the different personality traits. More specifically, regarding conscientiousness, the NEO FFI covers three facets (order, achievement-striving, and dutifulness). Research that considered the six PI-R facets of conscientiousness found that particularly achievement-striving and self-discipline seem to explain variance in students' GPA (Gray & Watson, 2002), whereas the conscientiousness facets of the PI-R were found to be unrelated to standardized achievement test scores (SAT verbal and SAT math; Nofle & Robins, 2007). These findings suggest that our consideration of the unbalanced NEO FFI might have resulted in an underestimation of the association between conscientiousness and GPA because we did not include the facet of self-discipline.

Research Prospects

There are a variety of aspects that will need closer consideration in future research, such as (a) identifying ways to more objectively derive a categorization of achievement features, (b) investigating PASH models with varying numbers of features, (c) integrating

prior theoretical models and the PASH, and (d) provide a full integration of PASH and the remaining personality traits.

Regarding (a), it is important to keep in mind that in this study, we focused on typical achievement domains (math and English), but in other domains, further factors might become relevant. In addition, our categorizations of achievement features in this manuscript were based on intensive literature reviews on the achievement measures and a validation process that involved communication with experts. This seems to be an adequate solution for categorizing some features and some measures (e.g., course grades are based on what was done in class and are therefore likely to have curricular validity and instructional sensitivity). However, this solution may be more challenging for other measures (e.g., instructional sensitivity for final examination grades might vary more strongly between groups of students) and could result in the need for study designs and data with strong requirements. For instance, to rigorously test for instructional sensitivity, extensive longitudinal data are needed to test for absolute and relative instructional sensitivity (Naumann et al., 2017). Likewise, the relevance of grades might vary between different students (independently of how grades count toward the final GPA), and studies would need to assess relevance at the student level to objectively derive appropriate aggregates. Regarding the curricular validity of measures, Nagy and Neumann (2010) proposed some options for deriving information about the alignment of the curriculum, using teacher judgments. Their results suggested that the majority of the TIMSS items exhibit curricular validity. The degree of standardization also requires researchers to assess process markers when deriving measures. As outlined in prior research, different teachers derive grades in quite different ways (Bowers, 2009; Brookhart, 2015; Hübner et al., 2020; Koretz, 2017). Assessing cognitive ability saturation would (at least) require them to administer sufficient cognitive ability tests and estimate the associations between these general cognitive abilities and the different achievement outcomes beforehand. At this point, we are not aware of any longitudinal studies that have used a broad set of achievement

measures and information (as outlined above) that would allow researchers to more objectively derive judgments about the standardization, relevance, curricular validity, instructional sensitivity, and cognitive ability saturation of achievement measures at the end of upper secondary school. In addition, how to best assess and derive these features of achievement measures is a research question of its own, which should be addressed more formally in future studies.

Regarding (b), the exact number of achievement features that are needed to adequately categorize different achievement measures remains an open research question to some extent. From a general perspective, the model should be parsimonious because, otherwise, the framework would get lost in detail, and the overlap between the different achievement features would naturally increase, making it even more difficult to derive specific hypotheses. We believe that the current version of the PASH consists of a well-balanced number of achievement features but that potential overlap between the features needs to be kept in mind. Importantly, although the features of cognitive ability saturation and instructional sensitivity describe different phenomenon, as can be seen in the theory section, they also share some ideas such that if the instructional sensitivity decreases, the cognitive ability saturation of a measure might increase. At the same time, there are plausible exceptions from this general tendency, in which specific tasks might be instructionally sensitive but might still depend a great deal on cognitive abilities (i.e., they might be highly saturated with cognitive ability). We therefore urge other researchers to more thoroughly consider and investigate different categorizations of achievement measures in future research.

Regarding (c), we see our study as a starting point from which researchers can more thoroughly consider differences between achievement measures and their features, whenever investigating student achievement. On the basis of the findings from the current paper, it might be fruitful to more formally integrate and test the Big Five-Narrow Traits Model (B5NT) model and the PASH in future studies, as both models provide unique contributions

to a better understanding of how personality traits and achievement measures are associated. It seems particularly important to further examine whether the narrow traits that mediate the association between personality traits and achievement according to the B5NT model vary when the achievement measures have different features. On the basis of previous research, it seems plausible to assume that, for instance, the generally stronger association between conscientiousness and grades might be explained by a stronger association between conscientiousness and self-concept, as found by Zhang and Ziegler (2016). Related to this, previous research has provided evidence that, compared with standardized achievement tests, grades are typically more strongly associated with self-beliefs and mediate associations between standardized achievement and self-concept (Marsh et al., 2005; Trautwein et al., 2006). In addition, besides indirect effects of personality on achievement via self-concept and learning approaches, Zhang and Ziegler (2016) still found direct effects of some achievement measures in some subjects, which might, at least in part, be reasonably explained by the features of the achievement measures. The PASH contributes to the existing research (e.g., the B5NT model) because it helps to better explain differential associations among different types of grades and between grades and standardized achievement tests by defining the features of achievement measures. This is a unique characteristic of the PASH that is currently not part of any other model or theory.

Finally, regarding (d), we focused primarily on better explaining the (differential) associations of two specific personality traits (openness and conscientiousness) with different achievement measures by more closely considering five specific features of achievement measures as articulated in the PASH. The specific focus on these two traits has been mirrored in most prior studies, which have typically theorized, found, and discussed the substantial associations that openness and conscientiousness have with academic achievement measures. In contrast to the findings for openness and conscientiousness, the associations between the remaining three personality traits (neuroticism, agreeableness, and extraversion) and

academic achievement have been less well-theorized, rather small, and found only inconsistently, thus constituting a challenge for a straightforward integration into the PASH (e.g., Lechner et al., 2017; Meyer et al., 2019; Poropat, 2009; Tetzner et al., 2019). The findings from our study for the three somewhat neglected personality traits were similar to those from prior studies: As can be seen in Figure 1 and Table 8, the associations with neuroticism, agreeableness, and extraversion seemed to be quite stable across the different achievement measures, and statistically significant differential associations were typically small in size. However, to more fully explain the associations between the personality traits and achievement measures, it will be important to widen the current research and also focus on the previously rather neglected traits. The PASH might provide a profound framework for doing so in future studies: For instance, as can be seen in Table 8, the associations between neuroticism and the achievement measures seemed more negative when cognitive ability saturation was clearly high but instructional sensitivity and relevance for the student were low. Differences between standardized tests and course grades in English might therefore be reasonably explained by one or a combination of these features. Extraversion might become more important the more relevant oral performance becomes for an achievement measure, and this might be the case in English more so than in mathematics. As can be seen, a full integration of the PASH and the remaining personality traits will require substantial theoretical and empirical consideration in future studies, particularly with respect to the stability of neuroticism, agreeableness, and extraversion across different achievement measures and the typically smaller effect sizes that are usually found.

Conclusion

In this study, we investigated the influence of personality traits on the most important academic achievement measures. Specifically, we were interested in explaining variation in these associations, as suggested by the PASH. We benefitted from data from three large-scale studies and aggregated these findings to ease interpretation. In line with the PASH, we found

differential result patterns, whereby conscientiousness was more predictive of measures that were lower on standardization, higher on curriculum validity, and higher on instructional sensitivity, and openness was particularly predictive of measures that were higher on standardization, lower on curriculum validity, lower on instructional sensitivity, and higher on cognitive ability saturation. The results call for a closer consideration of the impact of student characteristics on different achievement measures as articulated by the PASH.

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WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 1

Theoretical Features of the Achievement Measures that were the Focus of this Study and for Other Measures

Features	Standardization	Relevance for student	Curricular validity	Instructional sensitivity	Cognitive ability saturation
Achievement measures in this study					
Course grade	Low	Mod.-high	High	High	Moderate
Final examination grade	High	High	High	Low-mod.	Mod.- high
Grade point average	Rather Low	Mod.- high [†]	High	High	Mod.- high
Standardized test math	High	Low	High	Low	High
Standardized test English	High	Low	Low-mod.	Low	High
Other common achievement measures					
Standardized test (e.g., SAT)	High	High	Mod.	Low	High
State summative test (SST)	High	Mod. to high	High	High	x
Advanced placement test	High	High	High	High	x

Note. [†] The relevance of GPA is high for students, but GPA consists of many different grades, each of which contributes only a small share to the final GPA score. The relevance of each of these individual grades therefore varies from moderate to high. Mod. = moderate. Also note that previous research has provided some evidence of a stronger association of cognitive abilities with math than with verbal skills (e.g., Brandt et al., 2019; Meyer et al., 2019). The PASH assumes that the relative rank-order of achievement features within subjects (e.g., a higher cognitive ability saturation for standardized test scores than for grades) should be similar across different subjects, if not otherwise stated (e.g., for the curricular validity of the standardized test in English, compared with the standardized test in math). x = No accurate judgment possible, given available information/further evidence needed.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 2

Univariate Findings for Independent and Dependent Variables in the TOSCA 2002 Study, the TOSCA LAU Study, and the TOSCA 2006 Study

Variable	TOSCA 2002			TOSCA LAU			TOSCA 2006		
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>
CG Math: Basic	2,888	8.00	3.54	4,230	7.37	3.43			
CG Math: Advanced	1,633	9.61	3.05	963	8.87	3.23	4,879	8.22	3.52
CG English: Basic	2,376	8.71	2.80	3,102	7.83	2.72			
CG English: Advanced	1,628	9.33	2.71	1,481	9.39	2.76	4,361	8.81	2.88
FEG Math: Basic	2,562	7.52	3.95	1,321	8.81	3.63			
FEG Math: Advanced	1,577	9.08	3.79	922	7.84	3.89	4,862	7.66	4.12
FEG English: Basic	420	9.56	2.96	849	8.98	2.95			
FEG English: Advanced	1,566	8.76	3.41	1,457	8.86	3.01	2,789	8.73	3.32
Grade Point Average	4,403	2.37	0.64	4,977	2.32	0.62	4,768	2.42	0.63
Math test	4,664	500.00	100.00	5,110	500.00	100.00	4,879	500.00	100.00
English test	4,117	512.52	52.93	3,699	506.02	66.84	4,372	511.37	51.52
HISEI	4,479	58.40	15.64	3,230	59.47	15.97	4,744	57.37	15.67
Sex (women = 1)	4,682	0.54	0.50	5,275	0.54	0.50	4,852	0.55	0.50
Cognitive ability	4,667	100.00	15.00	5,236	100.00	15.00	4,911	100.00	15.00
Conscientiousness	4,464	2.89	0.45	1,472	3.36	0.62	2,116	2.84	0.45
Neuroticism	4,463	2.28	0.44	1,472	2.75	0.64	2,163	2.23	0.42
Agreeableness	4,466	2.92	0.36	1,469	3.51	0.54	2,116	2.93	0.36
Extraversion	4,469	2.85	0.40	1,468	3.68	0.72	2,168	2.86	0.39
Openness	4,463	2.76	0.44	1,456	3.66	0.56	2,124	2.68	0.41

Note. *N* = sample size, *M* = mean, *SD* = standard deviation. CG = course grade, FEG = final examination grade, Math Test = standardized achievement test in mathematics, English Test = standardized achievement test in English, HISEI = highest international socioeconomic index.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 3

Pooled Results of Manifest Intercorrelations Between Grades and All Other Variables From the TOSCA 2002 Study, the TOSCA LAU Study, and the TOSCA 2006 Study

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. CG Math: Basic	1	-																	
2. CG Math: Advanced	-	1																	
3. CG English: Basic	.32	.47	1																
4. CG English: Advanced	.38	.37	-	1															
5. FEG Math: Basic	.69	-	.36	.40	1														
6. FEG Math: Advanced	-	.74	.44	.39	-	1													
7. FEG English: Basic	.37	.50	.67	-	.34	.48	1												
8. FEG English: Advanced	.35	.38	-	.76	.43	.39	-	1											
9. Grade Point Average	.61	.72	.64	.73	.69	.74	.69	.70	1										
10. Math Test	.38	.52	.26	.28	.45	.66	.27	.27	.47	1									
11. English Test	.15	.25	.52	.57	.29	.40	.49	.58	.44	.37	1								
12. HISEI	.08	.11	.14	.15	.11	.16	.17	.13	.17	.12	.22	1							
13. Sex (female = 1)	.07	-.03	.04	.11	.04	-.11	.09	.12	.07	-.21	-.10	-.04	1						
14. Cognitive Ability	.21	.28	.18	.16	.24	.38	.15	.15	.26	.45	.35	.08	-.16	1					
15. Conscientiousness	.24	.21	.10	.14	.14	.13	.11	.08	.22	.06	-.06	-.03	.13	-.02	1				
16. Neuroticism	-.01	-.07	-.03	-.01	.03	-.08	.02	.05	-.03	-.11	-.07	-.04	.21	-.11	-.25	1			
17. Agreeableness	.05	.05	-.03	.03	.00	.02	-.02	.02	.02	-.02	-.06	-.01	.19	-.03	.21	-.19	1		
18. Extraversion	.03	-.07	-.05	-.03	-.05	-.09	-.08	-.08	-.05	-.11	-.06	.03	.11	-.07	.18	-.37	.27	1	
19. Openness	-.03	.02	.14	.20	.05	.04	.14	.20	.17	.03	.24	.10	.09	.03	-.04	.01	.06	.11	1

Note. p -values $p < .05$ are printed in bold. CG = course grade, FEG = final examination grade, Math Test = standardized achievement test in mathematics, English Test = Standardized achievement test in English, HISEI = Highest international socioeconomic index. For exact p -values, see Table S7 in the Supplemental Material.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 4

Pooled Results from Multiple Regressions Predicting Course Grades, Final Examination Grades, and Standardized Achievement-Test Scores from Personality Traits (Mathematics).

Dependent Variable	Course Grade						Final Examination Grade					
	Model I			Model II			Model I			Model II		
	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>
Predictor												
Conscientiousness	.24	.01	<.001	.24	.01	<.001	.16	.01	<.001	.17	.01	<.001
Neuroticism	-.04	.01	.002	.01	.01	.628	-.07	.01	<.001	.00	.01	.819
Agreeableness	.03	.01	.004	.03	.01	.012	.01	.01	.553	.01	.01	.325
Extraversion	-.14	.01	<.001	-.10	.01	<.001	-.14	.01	<.001	-.11	.01	<.001
Openness	-.02	.01	.119	-.03	.01	.016	.04	.01	.003	.02	.01	.137
R^2		.07			.17			.04			.17	
Standardized Achievement Test												
Conscientiousness	.05	.01	<.001	.06	.01	<.001						
Neuroticism	-.17	.01	<.001	-.03	.01	.001						
Agreeableness	-.02	.01	.055	.00	.01	.984						
Extraversion	-.18	.01	<.001	-.09	.01	<.001						
Openness	.05	.01	<.001	.07	.01	<.001						
R^2		.04			.33							

Note. Results are based on meta-analytic fixed effects models. All variables were *z* standardized. Results from the three studies were considered: TOSCA 2002, TOSCA LAU, TOSCA 2006. Coefficients from Model II were based on adjusted models including covariates (course level, socioeconomic background, general cognitive ability, and gender). See Table 6 for information about grade point average (all students).

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 5

Pooled Results from Multiple Regressions Predicting Course Grades, Final Examination Grades, and Standardized Achievement-Test Scores, from Personality Traits (English).

Dependent Variable	Course Grade						Final Examination Grade					
	Model I			Model II			Model I			Model II		
	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>
Predictor												
Conscientiousness	.16	.01	<.001	.14	.01	<.001	.12	.02	<.001	.10	.01	<.001
Neuroticism	-.01	.02	.614	-.02	.01	.104	.00	.02	.898	.02	.02	.145
Agreeableness	-.05	.02	.003	-.03	.02	.012	-.03	.02	.076	-.02	.02	.216
Extraversion	-.03	.02	.104	-.08	.01	<.001	-.09	.02	<.001	-.13	.01	<.001
Openness	.16	.02	<.001	.16	.02	<.001	.16	.02	<.001	.15	.02	<.001
<i>R</i> ²		.06			.13			.04			.10	
Standardized Achievement Test												
Conscientiousness	-.04	.02	.031	-.01	.01	.289						
Neuroticism	-.14	.02	<.001	-.06	.01	<.001						
Agreeableness	-.08	.02	<.001	-.03	.01	.003						
Extraversion	-.10	.02	<.001	-.08	.01	<.001						
Openness	.26	.01	<.001	.20	.01	<.001						
<i>R</i> ²		.08			.30							

Note. Results are based on meta-analytic fixed effects models. All variables were *z* standardized. Results from the three studies were considered: TOSCA 2002, TOSCA LAU, TOSCA 2006. Coefficients from Model II were based on adjusted models including covariates (course level, socioeconomic background, general cognitive ability, and gender). For English, we considered only students who selected English as a foreign language either as a basic or advanced course. See Table 6 for information about grade point average (English course subset).

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 6

Pooled Results from Multiple Regressions Predicting Grade Point Average from Personality Traits for all Students (mathematics) and the Subset of Students (English).

Dependent Variable	Grade Point Average (all students)						Grade Point Average (English course subset)					
	Model I			Model II			Model I			Model II		
Predictor	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>
Conscientiousness	.25	.01	<.001	.25	.01	<.001	.28	.02	<.001	.25	.01	<.001
Neuroticism	-.03	.01	.007	-.01	.01	.319	-.05	.02	.002	-.02	.01	.119
Agreeableness	-.02	.01	.212	-.03	.01	.003	-.07	.02	.166	-.02	.01	.055
Extraversion	-.12	.01	<.001	-.10	.01	<.001	-.10	.02	<.001	-.11	.01	<.001
Openness	.19	.01	<.001	.17	.01	<.001	.17	.01	<.001	.15	.01	<.001
R^2	.10			.19			.11			.19		

Note. Results are based on meta-analytic fixed effects models. All variables were *z* standardized. Results from the three studies were considered: TOSCA 2002, TOSCA LAU, TOSCA 2006. Coefficients from Model II were based on adjusted models including covariates (course level, socioeconomic background, general cognitive ability, and gender). English course subset: Due to the optional deselection of English as a foreign language, samples varied slightly between mathematics (mandatory selection: all students considered) and English (optional selection: subset of students considered). We therefore considered GPA separately for all students and those who chose English as a basic or advanced course.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 7

Pooled Results for the Multivariate Regression Models.

Subject	Mathematics						English					
	Course Grade vs. Test		Course Grade vs. FE Grade		FE Grade vs. Test		Course Grade vs. Test		Course Grade vs. FE Grade		FE Grade vs. Test	
Predictor	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
Conscientiousness	.17(.01)	<.001	.07(.01)	<.001	.10(.01)	<.001	.15(.01)	<.001	.04 (.01)	.002	.11(.01)	<.001
Neuroticism	.04(.01)	.003	.01(.01)	.546	.04(.01)	.001	.04(.01)	<.001	.00 (.01)	.833	.05(.01)	.001
Agreeableness	.03(.01)	.029	.02(.01)	.021	.01(.01)	.250	.01(.01)	.434	-.01 (.01)	.447	.02(.01)	.168
Extraversion	-.02(.01)	.250	.00(.01)	.720	-.02(.01)	.101	.00(.01)	.789	.05 (.01)	<.001	-.06(.01)	<.001
Openness	-.09(.01)	<.001	-.05(.01)	<.001	-.05(.01)	<.001	-.04(.01)	.001	.01 (.01)	.573	-.05(.01)	<.001
	Course Grade vs. GPA		GPA vs. FE Grade		GPA vs. Test		Course Grade vs. GPA		GPA vs. FE Grade		GPA vs. Test	
Conscientiousness	-.01(.01)	.535	.07(.01)	<.001	.18(.01)	<.001	-.11(.01)	<.001	.15(.01)	<.001	.26(.01)	<.001
Neuroticism	.02(.01)	.053	-.02(.01)	.036	.02(.01)	.069	.00(.01)	.794	.00(.01)	.749	.05(.01)	.001
Agreeableness	.05(.01)	<.001	-.03(.01)	.003	-.03(.01)	.019	-.01(.01)	.639	.00(.01)	.966	.02(.01)	.065
Extraversion	-.01(.01)	.409	.00(.01)	.823	-.01(.01)	.448	.02(.01)	.062	.03(.01)	.038	-.02(.01)	.080
Openness	-.20(.01)	<.001	.15(.01)	<.001	.10(.01)	<.001	.00(.01)	.746	.00(.01)	.887	-.04(.01)	<.001

Note. Results are based on meta-analytic fixed effects models. All variables were z standardized. Results from the three studies were considered: TOSCA 2002, TOSCA LAU, TOSCA 2006. All coefficients were taken from adjusted models (Model II). Grade = course grade, FE Grade = final examination grade, GPA= grade point average, Test = standardized achievement test.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Table 8

Summary of Results: Achievement Features and Personality Traits

Measure	Personality Trait				
	Conscientiousness	Neuroticism	Agreeableness	Extraversion	Openness
Mathematics					
Course grade	.24^{bc}	.01 ^c	.03^{cbd}	-.10	-.03^{bcd}
Final examination grade	.17^{acd}	.00 ^{cd}	.01 ^{ad}	-.11	.02 ^{acd}
Standardized test	.06^{abd}	-.03^{ab}	.00 ^{ad}	-.09	.07^{abd}
Grade point average	.25^{bc}	-.01 ^b	-.03^{abc}	-.10	.17^{abc}
English					
Course grade	.14^{bcd}	-.02 ^c	-.03	-.08^b	.16^c
Final examination grade	.10^{acd}	.02 ^c	-.02	-.13^{acd}	.15^c
Standardized test	-.01 ^{abd}	-.06^{abd}	-.03	-.08^b	.20^{abd}
Grade point average	.25^{abc}	-.02 ^c	-.02	-.11^b	.15^c

Note. Statistically significant associations are printed in bold and are based on results from Tables 4 and 5. Indices from a-d indicate statistically significant differences ($p < .05$) in the predictive power of different achievement measures based on Table 7. We considered only students who were enrolled in either an advanced or basic courses in English. For information on the categorization of measures to achievement features see Table 1.

^aDifferent from course grade. ^bDifferent from final examination grade. ^cDifferent from standardized test. ^dDifferent from grade point average.

WHEN ACADEMIC ACHIEVEMENT (ALSO) REFLECTS PERSONALITY

Figure 1. Average regression coefficients from using personality traits to predict grades, final examination grades, grade point average, and standardized achievement-test scores using results from the TOSCA 2002 study, the TOSCA LAU study, and the TOSCA 2006 study. Results are based on meta-analytic fixed effects models. Grey areas indicate 95% confidence intervals. The displayed results are based on models including covariates (Model II; see Tables 3 and 4). Grade = course grade, GPA = grade point average, Grade FE = final examination grade, Test = standardized achievement test.

Supplemental Material

Table S1

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, Standardized Achievement-Test Results, and GPA in Mathematics (Study 1: TOSCA 2002)

Dependent Variable Predictor	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.23(.02)	<.001	.22(.02)	<.001	.15(.02)	<.001	.14(.02)	<.001	.05(.02)	.001	.05(.01)	<.001	.23(.02)	<.001	.22(.02)	<.001
N	-.01(.02)	.560	.02(.02)	.345	-.03(.02)	.096	.02(.02)	.307	-.16(.02)	<.001	-.03(.01)	.005	-.02(.02)	.182	-.01(.02)	.756
A	.05(.02)	<.001	.04(.02)	.019	.02(.02)	.168	.02(.02)	.234	-.02(.02)	.173	.00(.01)	.73	.01(.02)	.612	-.01(.02)	.489
E	-.12(.02)	<.001	-.10(.02)	<.001	-.13(.02)	<.001	-.10(.02)	<.001	-.15(.02)	<.001	-.06(.01)	<.001	-.13(.02)	<.001	-.11(.02)	<.001
O	-.01(.02)	.690	.00(.02)	.937	.05(.02)	.007	.05(.02)	.003	.03(.02)	.059	.09(.01)	<.001	.22(.02)	<.001	.21(.02)	<.001
Sex (female)			.08(.02)	<.001			.04(.02)	.05			-.10(.02)	<.001			.13(.02)	<.001
HISEI			.08(.02)	<.001			.11(.01)	<.001			.08(.01)	<.001			.13(.02)	<.001
Cognitive Ability			.20(.01)	<.001			.26(.02)	<.001			.33(.01)	<.001			.23(.02)	<.001
Course Level (advanced)			.17(.02)	<.001			.13(.02)	<.001			.39(.02)	<.001			.13(.02)	<.001
R ²	.06		.15		.03		.14		.04		.39		.09		.19	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S2

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, and Standardized Achievement-Test Results, and GPA in English (Study 1: TOSCA 2002)

Dependent Variable	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
Predictor	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.19(.02)	<.001	.12(.02)	<.001	.13(.03)	<.001	.07(.02)	<.001	-.01(.03)	.764	-.03(.02)	.064	.30(.02)	<.001	.21(.02)	<.001
N	.04(.03)	.164	-.03(.02)	.139	.04(.04)	.290	-.03(.02)	.115	-.05(.03)	.103	-.06(.01)	<.001	-.02(.03)	.541	-.01(.02)	.436
A	-.10(.03)	.002	-.02(.02)	.156	-.07(.04)	.044	-.01(.02)	.573	-.11(.04)	.001	-.03(.01)	.034	-.14(.03)	<.001	.00(.02)	.948
E	.04(.03)	.224	-.11(.02)	<.001	-.08(.03)	.022	-.16(.02)	<.001	-.06(.03)	.049	-.09(.01)	<.001	-.04(.03)	.234	-.12(.02)	<.001
O	.11(.03)	<.001	.20(.02)	<.001	.12(.03)	<.001	.19(.02)	<.001	.19(.03)	<.001	.22(.01)	<.001	.13(.03)	0	.19(.02)	<.001
Sex (female)			.08(.02)	<.001			.08(.02)	.001			-.07(.02)	<.001			.11(.02)	<.001
HISEI			.10(.02)	<.001			.09(.02)	<.001			.11(.02)	<.001			.12(.02)	<.001
Cognitive Ability			.19(.02)	<.001			.18(.02)	<.001			.32(.02)	<.001			.26(.02)	<.001
Course Level (advanced)			.11(.02)	<.001			.08(.02)	.001			.40(.02)	<.001			-.05(.02)	.001
R ²	.05		.121		.03		.11		0.04		.35		.10		.17	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S3

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, Standardized Achievement-Test Results, and GPA in Mathematics (Study 1: TOSCA LAU)

Dependent Variable	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
Predictor	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.28(.03)	<.001	.29(.03)	<.001	.2(.03)	<.001	.23(.03)	<.001	.05(.03)	.049	.07(.03)	.006	.30(.02)	<.001	.31(.02)	<.001
N	-.08(.03)	.005	-.03(.03)	.254	-.03(.04)	.358	.00(.04)	.985	-.17(.03)	<.001	-.04(.03)	.132	-.02(.03)	.569	.01(.03)	.683
A	-.06(.03)	.058	-.05(.03)	.071	-.13(.04)	<.001	-.13(.04)	.001	-.04(.03)	.160	-.01(.02)	.699	-.15(.03)	<.001	-.15(.02)	<.001
E	-.11(.03)	<.001	-.07(.03)	.032	-.11(.04)	.003	-.08(.04)	.02	-.21(.03)	<.001	-.11(.02)	<.001	-.04(.03)	.195	-.01(.03)	.806
O	-.04(.03)	.153	-.07(.03)	.02	.00(.03)	.989	-.04(.03)	.194	.06(.03)	.054	.04(.02)	.098	.14(.03)	<.001	.10(.03)	<.001
Sex (female)			.12(.02)	<.001			.17(.02)	<.001			.10(.02)	<.001			.22(.02)	<.001
HISEI			.03(.02)	.129			.00(.02)	.926			-.07(.02)	<.001			.07(.02)	<.001
Cognitive Ability			.25(.02)	<.001			.27(.02)	<.001			.35(.01)	<.001			.25(.02)	<.001
Course Level (advanced)			.10(.02)	<.001			-.08(.02)	<.001			.32(.02)	<.001			.03(.02)	.078
R ²	.08		.18		.05		.16		.05		.33		.10		.22	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S4

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, and Standardized Achievement-Test Results, and GPA in English (Study 1: TOSCA LAU)

Dependent Variable	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
Predictor	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.16(.03)	<.001	.19(.03)	<.001	.12(.03)	<.001	.14(.03)	<.001	-.05(.05)	.298	.04(.02)	.089	.28(.03)	<.001	.32(.02)	<.001
N	.00(.03)	.930	.03(.03)	.342	.01(.04)	.815	.03(.04)	.385	-.14(.05)	.006	.01(.03)	.873	-.05(.03)	.122	.00(.03)	.947
A	-.14(.04)	<.001	-.10(.03)	.001	-.11(.04)	.008	-.08(.03)	.024	-.21(.06)	<.001	-.08(.03)	.009	-.17(.04)	<.001	-.14(.03)	<.001
E	.02(.04)	.599	.02(.03)	.467	-.09(.04)	.022	-.07(.03)	.029	-.09(.06)	.134	-.05(.03)	.058	-.05(.04)	.172	-.02(.03)	.490
O	.20(.03)	<.001	.07(.03)	.009	.19(.03)	<.001	.09(.03)	.006	.38(.03)	<.001	.14(.03)	<.001	.20(.03)	0	.09(.03)	<.001
Sex (female)			.08(.02)	<.001			.08(.02)	<.001			-.05(.02)	.013			.06(.02)	.001
HISEI			.16(.02)	<.001			.14(.02)	<.001			.22(.02)	<.001			.21(.02)	<.001
Cognitive Ability			.16(.02)	<.001			.18(.02)	<.001			.32(.02)	<.001			.25(.02)	<.001
Course Level (advanced)			.24(.02)	<.001			.10(.02)	<.001			.35(.02)	<.001			.07(.02)	<.001
R ²	.09		.17		.05		.10		.19		.33		.12		.21	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S5

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, Standardized Achievement-Test Results, and GPA in Mathematics (Study 1: TOSCA 2006)

Dependent Variable	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
Predictor	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.23(.02)	<.001	.25(.02)	<.001	.16(.03)	<.001	.20(.02)	<.001	.05(.02)	.057	.10(.02)	<.001	.26(.02)	<.001	.26(.02)	<.001
N	-.06(.02)	.011	.01(.02)	.649	-.12(.02)	<.001	-.02(.02)	.408	-.17(.02)	<.001	-.04(.03)	.135	-.07(.02)	.004	-.04(.02)	.079
A	.06(.03)	.014	.07(.02)	.002	.03(.03)	.221	.05(.02)	.020	-.01(.03)	.606	.02(.02)	.311	.03(.03)	.213	.02(.02)	.351
E	-.18(.02)	<.001	-.14(.02)	<.001	-.18(.02)	<.001	-.13(.02)	<.001	-.20(.02)	<.001	-.13(.02)	<.001	-.14(.02)	<.001	-.13(.02)	<.001
O	-.02(.02)	.265	-.05(.02)	.008	.04(.02)	.085	.00(.02)	.888	.08(.02)	<.001	.05(.02)	.015	.19(.02)	<.001	.15(.02)	<.001
Sex (female)			.09(.02)	<.001			.12(.02)	<.001			.10(.02)	<.001			.14(.02)	<.001
HISEI			-.01(.02)	.431			-.06(.02)	<.001			-.15(.02)	<.001			.10(.02)	<.001
Cognitive Ability			.28(.02)	<.001			.38(.02)	<.001			.38(.01)	<.001			.26(.02)	<.001
R ²	.08		.17		.06		.23		.05		.24		.11		.20	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S6

Multiple Regressions using Personality to Predict Grades in 13.1, Final Secondary-School Examination Grade, and Standardized Achievement-Test Results, and GPA in English (Study 1: TOSCA 2006)

Dependent Variable	Course Grade				Final Examination Grade				Standardized Achievement Test				GPA			
Predictor	Model I		Model II		Model I		Model II		Model I		Model II		Model I		Model II	
	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p	$\beta(SE)$	p
C	.14(.02)	<.001	.14(.02)	<.001	.12(.03)	<.001	.11(.03)	<.001	-.06(.02)	.021	-.02(.02)	.283	.25(.03)	<.001	.26(.02)	<.001
N	-.05(.02)	.052	-.05(.02)	.054	-.03(.03)	.262	-.03(.03)	.238	-.19(.03)	<.001	-.11(.02)	<.001	-.07(.02)	.003	-.04(.02)	.077
A	.02(.03)	.440	.01(.03)	.823	.02(.03)	.395	.01(.03)	.817	-.03(.03)	.208	-.02(.02)	.432	.03(.03)	.240	.02(.02)	.380
E	-.10(.03)	<.001	-.10(.03)	<.001	-.11(.03)	<.001	-.11(.03)	<.001	-.14(.03)	<.001	-.10(.03)	<.001	-.14(.02)	<.001	-.13(.02)	<.001
O	.17(.03)	<.001	.14(.03)	<.001	.16(.03)	<.001	.13(.03)	<.001	.24(.02)	<.001	.20(.02)	<.001	.19(.02)	<.001	.14(.02)	<.001
Sex (female)			.13(.02)	<.001			.13(.03)	<.001			.16(.02)	<.001			.14(.02)	<.001
HISEI			.12(.02)	<.001			.13(.02)	<.001			-.03(.02)	.168			.10(.02)	<.001
Cognitive Ability			.15(.02)	<.001			.17(.02)	<.001			.32(.02)	<.001			.26(.02)	<.001
Course Level (advanced)			.14(.02)	<.001			.11(.02)	<.001			-.02(.02)	.283			.26(.02)	<.001
R ²	.05		.10		.05		.10		.10		.23		.11		.20	

Note. β : All values are fully standardized; HISEI = highest international socioeconomic index; CL = course level. C = conscientiousness, N = neuroticism, A = agreeableness, e = Extraversion, o = Openness.

Table S7

Exact p-values for all $p > .001$

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Math: Basic	<.001	-																	
2. Math: Advanced	-	<.001																	
3. English: Basic	<.001	<.001	<.001																
4. English: Advanced	<.001	<.001	-	<.001															
5. Math: Basic	<.001	-	<.001	<.001	<.001														
6. Math: Advanced	-	<.001	<.001	<.001	-	<.001													
7. English: Basic	<.001	<.001	<.001	-	<.001	<.001	<.001												
8. English: Advanced	<.001	<.001	-	<.001	<.001	<.001	-	<.001											
9. Grade Point Average	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001										
10. Math Test	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001									
11. English Test	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001								
12. HISEI	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001							
13. Sex (f = 1)	<.001	.027	.002	<.001	.007	<.001	.002	<.001	<.001	<.001	<.001	<.001	<.001						
14. Cognitive Ability	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001					
15. Conscientiousness	<.001	<.001	<.001	<.001	<.001	<.001	.006	<.001	<.001	<.001	<.001	.004	<.001	.109	<.001				
16. Neuroticism	.464	<.001	.103	.597	.080	<.001	.647	.008	.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001			
17. Agreeableness	<.001	<.001	.103	.041	.897	.265	.535	.234	.068	.028	<.001	.434	<.001	.015	<.001	<.001	<.001		
18. Extraversion	.053	<.001	.006	.031	.004	<.001	.033	<.001	<.001	<.001	<.001	.002	<.001	<.001	<.001	<.001	<.001	<.001	
19. Openness	.098	.347	<.001	<.001	.003	.010	<.001	<.001	<.001	.024	<.001	<.001	<.001	.003	<.001	.329	<.001	<.001	<.001

Note. CG = course grade, FEG = final examination grade, Math Test = standardized achievement test in mathematics, English Test = Standardized achievement test in English, HISEI = Highest international socioeconomic index.