Aberrant personality tendencies and academic success throughout engineering education

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**Aberrant personality tendencies and academic success throughout engineering
education**

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Abstract

Objective: In a longitudinal field study, we investigated the predictive associations between six aberrant personality tendencies (antisocial, narcissistic, borderline, schizotypal, obsessive-compulsive, avoidant) and academic success of STEM students.

Method: Bachelor students of Industrial Engineering at a Dutch technical university ($N = 432$, $M_{\text{age}} = 18.45$; 87.3% male) filled out the NEO-PI-R and aberrant tendencies were operationalized by the five-factor model compound technique. Indicators of academic achievement (grades) and persistence (credit points earned per year, re-enrollment, study duration) were made available by the academic office.

Results: Validities across the three years of the study program consistently support the role of two aberrant tendencies: Individuals with high antisocial tendency reached lower academic achievement, took longer to finish their study, and had a higher risk of drop out. The obsessive-compulsive tendency was associated with higher grade-point-average, faster study progress, and higher retention rates and effects were still visible while controlling for known predictors (high school grades, Conscientiousness). Contrary to our expectations, we found no evidence for inverted U-shape relationships.

Conclusions: We used the compound technique for aberrant tendencies based on the five-factor model in the academic context and our findings support the importance of personality-based psychopathological tendencies for academic success.

Keywords. Aberrant personality tendencies, longitudinal validation, academic success, STEM students.

Several meta-analyses support the relevance of personality traits for academic success (e.g., Poropat, 2009; Richardson, Abraham, & Bond, 2012). For example, among the Big Five personality factors, Conscientiousness (C) has been shown to be the strongest predictor (e.g., Poropat, 2014; Schneider & Preckel, 2017). In addition, dark personality traits have been found to be useful to predict and understand behavior (e.g., at work, Spain, Harms, & LeBreton, 2015). However, not much is known about the positive and/or negative effects of a broad spectrum of aberrant personality traits (Wille, De Fruyt, & De Clercq, 2013) on personal functioning in the academic context. Therefore, the goal of the current study was to examine in a longitudinal field study the positive and negative effects of a broad spectrum of aberrant personality tendencies (APT; schizotypal, avoidant, borderline, antisocial, narcissistic, and obsessive-compulsive) on academic success in a Bachelor program (Industrial Engineering) at a Technical University. First, prior findings on personality and academic performance are mainly based on samples of psychology students even though research findings suggest that the relationship is influenced by the type of study program (Vedel, 2014). From a practical point of view, especially technical universities (in the U.S. as well as in Europe) face vast problems in terms of a high industry demand for STEM (science, technology, engineering, and mathematics) professionals combined with high dropout rates and only a small proportion of students completing the program in the designated study period (Chen & Solder, 2013). Therefore, there is a need to better understand the role of personality traits for academic success for such study programs, in order to provide advice for the optimization of admission or counseling procedures at (technical) universities. Second, prior studies have mainly focused on grade point average (GPA) as outcome indicator and hence the role of personality traits for other indicators of academic success (see different components of academic success in the conceptual model of York, Gibson, & Rankin, 2015) is less clear. We therefore also investigated the role of APT for persistence in terms of

retention and study progress. Third, we investigated the relevance of APT above and beyond high school GPA and Conscientiousness, both known predictors of academic success. Fourth, extending prior findings on the relationship of APT with career outcomes (Wille et al., 2013), we examined besides linear also non-linear relationships with academic success and investigated their long-term predictive validity across a three-year Bachelor program.

Theoretical Background

Aberrant Personality Tendencies (APT)

Derived from the most recent clinical taxonomy of personality dysfunction (DSM-5: www.dsm5.org), the APT investigated in the current study represent a quantitative approach to conceptualizing personality peculiarities that may have an impact on daily functioning (e.g., at the university). We focused on six APT (following Wille et al., 2013) – a selection out of the 10 personality disorders included in the DSM-5: schizotypal, avoidant, borderline, antisocial, narcissistic, and obsessive-compulsive tendencies. First, these six tendencies have been suggested by the Personality and Personality Disorder Work Group to be retained from the DSM-5 (Skodol et al., 2011; Skodol, 2012) as these have the highest prevalence in community and clinical samples, most strongly impair individual functioning, and empirical research has demonstrated their validity and utility. Second, they span a broader range of aberrant personality characteristics than the dark triad of personality (Machiavellianism, psychopathy, and narcissism). Third, while latter traits are mainly expected to lead to problematic behaviors (e.g., counterproductive behavior, O'Boyle Jr., Forsyth, Banks, & McDaniel, 2012), we expected based on prior findings (Wille et al., 2013) on the aberrant tendencies investigated in the current study, that they not only have a negative but in some cases also a positive impact on academic success.

Taking into account that personality disorders have been shown to have substantial overlap with general personality traits (such as from the five-factor model, FFM), Lynam and

Widiger (2001) presented a successful prototype matching technique, in which they obtained FFM profiles for the personality disorders defined in the DSM, based on expert's ratings of the relevance of the Five Factors for these disorders. Subsequently, a simplified technique to score personality disorders by computing a linear combination from the 30 facets scores of the FFM was introduced (e.g., Miller, Bagby, Pilkonis, Reynolds, & Lynam, 2005; Miller et al., 2008). Such compound techniques can be used to screen for dysfunctional personality tendencies in various contexts and have already been successfully applied in clinical samples (e.g., Miller, et al., 2005) or the work context (e.g., De Fruyt, Wille, & Furnham, 2013).

Predictors of Academic Success in STEM

Intelligence, achievement measures (e.g., college admission tests such as the scholastic aptitude test), and school grades are well-established predictors of academic success (Kuncel & Hezlett, 2010; Trapmann Schuler, Hell, Hirn & Schuler, 2007). Several meta-analyses support their predictive validity with medium to large effect sizes, for example, with regard to achievement in higher education (Schneider & Preckel, 2017; $d = .90$ for high school GPA, 95% CI [.77, 1.04]). However, these indicators are far from explaining all of the variance in academic success, and several meta-analyses confirm the role of non-cognitive measures for academic achievement. Recently, Schneider and Preckel (2017) demonstrated that the effect sizes of C for predicting academic achievement are comparable for the ones found for intelligence (both with Cohen's $d = 0.47$).

Many prior studies linking non-cognitive predictors to academic success concentrated on a single outcome indicator: GPA. Although not without criticism, GPA has been shown to generally be a robust and objective measure of academic achievement (Richardson et al., 2012). Recently, York et al. (2015) reviewed the educational research literature and suggested six different components of academic success: academic achievement, satisfaction, acquisition of skills and competencies, persistence, attainment of learning outcomes, and

career success. This raises the question how established and (relatively) new predictors are related to other outcomes than GPA in the academic context. Indeed, meta-analytic evidence suggests that the validity of personality traits varies depending on the criterion investigated (Trapmann et al., 2007). Non-cognitive predictors may be of higher relevance for other criteria than academic accomplishments, such as teamwork or sustained effort during the study (Camara, 2005). Nonetheless, research investigating the relationship of personality traits to indicators of academic success other than GPA is scarce (Trapmann et al., 2007), especially for STEM students. For psychology majors, study findings point toward a positive effect of C on retention in the first year (Alarcon & Edwards, 2013), and a negative relation with the intention to withdraw from college (Lounsbury, Saudargas, & Gibson 2004). In addition, De Fruyt and Mervielde (1996) found that students of various faculties (that included engineering students) who scored higher on C needed fewer re-exams to complete the program. Talbot (1990) reported for a sample consisting of psychology and general physics students that, besides high school GPA, also individual differences (e.g. need for cognition) are relevant for academic persistence (e.g., the number of courses passed).

Building on York et al.'s (2015) conceptual model, we investigated two central but distinct outcomes of academic success: *academic achievement* (measured by grades and GPA across the study program), and *persistence* (retention after the first year, study progress measured by the number of credit points earned, and study duration). Although there might be a potential trade-off between these indicators in terms of quality and quantity (more courses completed with low grades vs. a few courses completed with high grades), we expected - in line with empirical evidence (Robbins et al., 2004) - a positive correlation between the two indicators of academic success and comparable relationships with APT. Especially in the beginning of a study program, attrition seems to be closely related to academic achievement.

For example, Lievens, Ones, and Dilchert (2009) found that students who leave medical school early score lower on C, and that this trait also shows essential validity for GPA.

Hypothesis: APT and Academic Success of STEM students

The few studies that looked into the effects of aberrant personality tendencies on academic success typically only investigated the relevance of selected or dark triad constructs (e.g., Furnham, Richards, & Paulhus, 2013), or focused on linear relationships (King, 2000). To our knowledge, no prior study has investigated the predictive validity of a broad range of APT based on the FFM for different indicators of academic success in higher education at a technical university across several years. We formulated our expectations about the effect of APT on academic success by relying on explanatory models for academic achievement and educational persistence (for an overview see Robbins et al., 2004), that include various variables that impact learning and persistence, for example, in terms of cognition, motivation, affect, and behavior. Personality traits have been shown to affect distal consequences (such as learning and academic performance) via proximal consequences in terms of self-regulation (e.g., goals, self-efficacy, learning strategies; Philips, Abraham, & Bond, 2003; Zhang & Ziegler, 2018). Given the effect of APT on various of these self-regulatory learning processes in the educational context (e.g., affect, cognitions, and behavior), we expected vital relationships with academic success for five of the six aberrant tendencies.

Criterion-related validity. We expected three of the APT to be negatively related to academic success: *borderline* (which refers to instability of personal relationships, emotions, and insecurity), *schizotypal* (which goes with being socially anxious and suspicious, odd behavior, and unconventional beliefs), and *antisocial* (i.e., impulsive, hot-tempered, irritable, aggressive, lack of remorse). Our expectations were based on the detrimental consequences on self-regulatory behavior associated with these tendencies, in terms of affect (e.g., instability), cognitions (e.g., lowered self-concept, cognitive deficits), or potentially harmful

effects on interpersonal behavior (e.g., getting into arguments with others) that can impair functioning in the academic context.

First, *borderline* personality disorders have been shown to impair the process of adjustment to the role of being a student, which can be explained by problems in building and keeping interpersonal relationships, instability in affect, or cognitive deficits (Bagge et al., 2004). Furthermore, studies have shown that self-efficacy is strongly related to achievement in higher education (Schneider & Preckel, 2017). Therefore, a poor self-concept that is inherent in borderline tendency could lead to lower GPA and higher dropout from the study. Second, *schizotypal* disorders encompass cognitive deficits that negatively impact the learning process (Knights & Kennedy, 2007). Also, the associated problems with this tendency with regard to social interactions may have a negative impact on academic functioning. Studies have shown that social skills affect academic success in terms of GPA and attrition (Strahan, 2003). These aspects are likely to critically affect academic success in design-based STEM programs with a high rate of group work. Aguirre, Sergi, and Levy (2008) found that students scoring high on schizotypy have problems in terms of academic functioning, for example, in keeping up with their coursework, regularly attending classes, or a tendency to get into arguments with others. Third, the *antisocial* tendency shows a high overlap with psychopathy (Decuyper, De Pauw, De Fruyt, De Bolle, & De Clercq, 2009), a trait characterized by impulsivity and irresponsibility, that may manifest itself in problematic interpersonal behaviors, a tendency to lie, or high risk-taking (Wu & Lebreton, 2011). For example, antisocial characteristics (low scores on Agreeableness and C) have been found to be associated with cheating behavior (Williams, Nathanson, & Paulhus, 2010) that can undermine academic success. Indirect support stems from Van Eerde (2004) who found strong relationships of Neuroticism facets (some of which are used to calculate these three APT in the compound technique) with the tendency to procrastinate. Our anticipated

relationships are also supported by prior study findings, which have shown negative relationships of borderline (Trull, Useda, Conforti, & Doan, 1997), schizotypal, and antisocial (King, 1998) personality disorder scales with academic outcomes.

We expected two of the APT to be positively related to academic success (at least to a certain degree, see the following section on curvilinear relationships): *obsessive-compulsive* (e.g., aspects related to perfectionism, orderliness, and inflexibility) and *avoidant* (e.g., encompassing sensitivity to negative evaluation, feelings of inadequacy) tendencies. This expectation is based on their potential benefit for self-regulatory or motivational processes (e.g., goals, effort). First, although an obsessive-compulsive personality disorder might lead to dysfunctional behaviors at the university, such as rigidity, or problems in interactions with others (Ettner, Maclean, & French, 2011), these tendencies have also been shown to be associated with interpersonal strategies that focus on moving towards (in contrast to moving against or away, like antisocial or borderline tendencies; Knights & Kennedy, 2007). Students with obsessive-compulsive characteristics are expected to hold high standards for themselves, strive for perfection, and value achievement and productivity (especially over social interactions) (De Fruyt et al., 2009), which may lead to higher performance. Further, indirect support for such an expected positive effect, can be obtained by examining the compound technique based on the FFM. First of all, all C subfacets go into the calculation of this tendency, many of which (e.g., achievement, self-discipline) have been shown to lead to higher GPA or persistence in the academic context (e.g., Nofle & Robins, 2007). However, research supports that the obsessive-compulsive personality disorder has essential relationships with other Big Five traits (Mike, King, Oltmanns, & Jackson, 2018). In particular, facets of O (reversed) are used to build this tendency, for some of which Lievens et al. (2009) found a negative relationship (openness to actions and values) to student performance (at least in the beginning of medical school). Given that the STEM study

program investigated in the current study did not allow for many individual choices in the BA and focusses on mathematics and technology instead of creativity or design aspects, it can be expected that students who, for example, prefer routines over variety (low openness to values) or who seldom get emotional and are oriented towards facts (low openness to feelings), reach higher academic success.

Second, Wille et al. (2013) concluded on the basis of the existing literature, that the functioning of individuals with an avoidant tendency may not be impaired in non-threatening environments. Bornstein and Kennedy (1994) argued that persons concerned with avoiding negative evaluations from others will invest higher effort and show increased motivation to perform well academically. Indeed, studies in the educational context have demonstrated that avoidant personality features may be beneficial for academic performance, for example, by positively affecting classroom attendance (King, 2000).

H1: a) Borderline, b) schizotypal, and c) antisocial personality tendencies will be negatively, and d) avoidant and e) obsessive-compulsive tendencies will be positively related to academic success.

For the narcissistic tendency, inconsistent prior results lead us to not hypothesize a particular direction of a relationship with academic success. While narcissism seems to be associated with elevated self-reports, King (2000) found no systematic relationship of narcissistic personality disorders with objective academic performance. Other study findings point towards an association of narcissism with problematic behaviors in the academic context, such as cheating, or academic entitlement (e.g., Brunell, Staats, Barden, & Hupp, 2011; Turnipseed & Cohen, 2015). In contrast, Wille et al. (2013) found that persons with a narcissistic tendency tend towards higher hierarchical or financial attainment in their career.

Curvilinear relationships. Growing empirical evidence suggests that the relationship between personality traits and performance may be more complex in nature than a pure linear

relation (Converse & Oswald, 2014). For example, Cucina and Vasilopoulos (2005) presented evidence on an inverted U-shape relationship of C with academic performance. On a theoretical level, Le et al. (2011) suggest that too much of C might lead to compulsive perfectionism, with, for example, too much focus given to (unnecessary) details, engaging in dysfunctional self-deception, or becoming inflexible and rigid, which hampers performance. Although non-linear relationships have been reported for related dark personality traits (e.g., Benson & Campbell, 2007), to our knowledge, no prior study has tested such relationships for APT in the educational context. In line with the antecedent-benefit-cost framework (Busse, Mahlendorf, & Bode, 2016), we expected that avoidant and obsessive-compulsive tendencies may only be beneficial for academic success up to a certain point, so that when scores get from moderate to high they may be associated with increasing emotional or cognitive costs, in a way that dysfunctional self-regulatory behavior becomes dominant which negatively impacts academic success. For example, an obsessive-compulsive tendency may lead to maladaptive perfectionism, overly rigidity, stubbornness, or to severe problems in terms of interpersonal functioning (e.g., Ettner et al., 2011). An avoidant tendency may be associated with an extreme fear of being criticized or rejected that may lead to the complete avoidance of situations in which one's performance is evaluated (such as classes and tests).

H2: a) Avoidant and b) obsessive-compulsive tendencies will have an inverted U-shape relation to academic success: the relationship is initially positive but becomes negative as the scores on these APT increase.

Incremental validity. Given that prior research has documented that school grades are a well-established predictor of academic performance, we tested whether the APT affect academic outcomes while controlling for differences attributable to this traditional predictor. Comparable to the incremental validity of personality traits above and beyond high school

GPA (Richardson et al., 2012), we expected that APT is systematically related to academic success while controlling for prior performance.

H3: a) Borderline, b) schizotypal, c) antisocial, d) avoidant, and e) obsessive-compulsive tendencies demonstrate incremental validity over and above high school GPA for academic success.

In addition, we tested if APT are related to academic success in the study program beyond the effects of high school GPA and general FFM traits. In particular, C is of interest here, as this trait has been shown to be the strongest predictor of academic achievement in tertiary education (e.g. Poropat, 2009). Notwithstanding the inherently high overlap between the FFM traits and aberrant personality compounds, Wille et al. (2013) were able to demonstrate incremental validity for APT with regard to career outcomes.

H4: a) Borderline, b) schizotypal, c) antisocial, d) avoidant, and e) obsessive-compulsive tendencies demonstrate incremental validity over and above high school GPA and C for academic success.

Validity across study program. Although personality traits have been shown to have predictive validity for academic success, their impact during the course of a study program is less well understood. Knowledge about longer-term effects of non-cognitive predictors seems essential, as the nature of the study program may change throughout the years and students thus may need to adapt. Lievens et al. (2009) showed that personality traits become even more relevant over the course of a study program in medical school. Potential explanations for that might be, that at the beginning of the study program a “honeymoon” effect of a new situation and novel tasks at the university may create dominant demands, masking personality effects (see trait activation theory, Tett & Burnett, 2003). In addition, the nature of the courses taught in medical school changes from more knowledge-driven in the beginning to applied courses that require more interaction with patients later in the study program, for which

personality traits that address social interactions may become more relevant. To some extent, this may also occur in STEM programs, in which courses tend to change from mainly knowledge-driven at the beginning of the study program (e.g., mathematics, methodology), to more group-based and applied work that requires interactions in courses and projects in the later stage of the study program. Given that personality disorders have been shown to have medium to large associations with various dysfunctional interpersonal styles (Wilson, Stroud, & Durbin, 2017), we expected APT to become even more relevant in later stages of the study program.

H5: The importance of a) borderline, b) schizotypal, c) antisocial, d) avoidant, and e) obsessive-compulsive tendencies for academic success will increase in the course of the study program.

Method

Participants and Procedure

To test our hypotheses, we collected data in a longitudinal field study among three cohorts of undergraduate students in a three-year Bachelor (BSc.) program in Industrial Engineering at a Dutch technical university ($N = 459$). Students started their undergraduate studies in the fall of 2009 ($n = 184$), 2010 ($n = 120$), and 2011 ($n = 155$). The program encompassed 180 credit points (1 CP = 28 hours of study load): 141 CP of courses (mathematics & statistics, technology & engineering, and management science courses), a 30 CP minor program (the only curriculum component that varied among students depending on their personal choices), and a 9 CP final project. In the second and third year, 56 CP were characterized as design-based learning. The curricula for the three cohorts consisted of the same courses, with minor changes for cohort 2011 (a slight reordering of courses in the second year). All students received a mandatory study advice: they had to leave the study program at the end of the first year if they had not earned at least 30 CP. Therefore, the

highest (forced) dropout occurred in the first year, with only minor dropout thereafter. Of the 304 students who remained in the program after the first year, 270 completed the program (58.8% of the students who enrolled in the first year graduated).

As part of a larger longitudinal research project, students participated in an extensive assessment in the first six weeks of the study. Among other things, they completed a personality questionnaire. Participation in the study was voluntary, but bonus points in an exam and individual feedback reports on personality were offered as incentives. We thus ensured a high response rate of 94.1%, with complete data obtained from 432 students. The mean age was 18.45 (range: 17 - 30) years, with most students entering the program immediately after finishing high school (81.6% of the sample was 18 or 19 years old). The majority of the sample was male (87.3%), which is common for such a study program.

Measures

Aberrant personality tendencies. Students completed the authorized Dutch adaptation (Hoekstra, Ormel, & De Fruyt, 2007) of the NEO-PI-R (Costa & McCrae, 1992), which assesses the Big Five personality factors with six subfacets for each trait (8 items per subfacet). In total, 240 items are answered on a 5-point Likert scale ranging from *strongly agree* to *strongly disagree*. Scores on the schizotypal, avoidant, borderline, antisocial, narcissistic, and obsessive-compulsive tendencies were calculated on the basis of a specific linear combination of selected Big Five subfacets (Miller et al., 2005; Miller et al., 2008), as applied in previous research (scoring rules see Wille et al., 2013). For example, the obsessive-compulsive tendency is calculated on the basis of a linear combination of in total 13 subfacets across the NEO-PI-R, namely: N1 Anxiety + N5 Impulsiveness (reverse scored, R) + E5 Excitement seeking (R) + O3 Feelings (R) + O4 Actions (R) + O5 Ideas (R) + O6 Values (R) + C1 Competence + C2 Order + C3 Dutifulness + C4 Achievement striving + C5 Self-discipline + C6 Deliberation. For the global Big Five factors, Cronbach's alpha varied

between .93 and .95. Reliability estimates for aberrant tendencies were obtained by applying the formula provided by Nunnally (1978, p. 246ff.) for linear combinations of traits.

Academic success. Indicators of academic achievement (grades, GPA) and persistence (retention in terms of re-enrollment in the second year; study progress in terms of CP earned per year; total study duration of the BSc. program in months) were made available by the department's academic office at the end of each academic year. In the Dutch grading system, grades vary from 1 to 10, with higher grades indicating better performance; conversion to U.S. grading system: 9/10 = A+, 8 = A, 7 = B+, 6.5 = B, 6 = C, 0 - 5 = F (Nuffic, 2013). Students typically pass a course with a grade of at least 6. With regard to study progress, the nominal study program is 60 CP per year. Given that the academic year at the university was split into four quarters, students were able to complete their study at different points in time (five times per year, including an interim examination period in the summer). Overall, it took students between 34 to 83 months to complete the three-year program ($M = 44.29$, $SD = 10.29$ months). We investigated GPA and CP earned over the nominal three consecutive years of the study program (i.e. after 12, 24, and 36 months). At the (individual) moment of completing the study program, we calculated GPA and the study duration. We assessed retention by registering the students who re-enrolled in the next academic year.

Analysis strategy

First (H1), to answer the question if and how APT are related to academic success, zero-order correlations with GPA (in each academic year, overall) and study progress (CP earned, study duration) were calculated. For retention, we compared personality characteristics of leavers vs. persisters after the first year of the study with a MANCOVA. Given the number of analyses executed, we used a more stringent significance level ($p < .01$) for these analyses.

Second (H2), we tested the inverted U-shape relationships by means of the recently suggested two-lines approach by Simonsohn (2018), using the provided online tool

(<http://webstimate.org/twolines/>; version 0.34). Optimizing statistical power, the test estimates two different regression lines (one for low to moderate values, one for moderate to high values of the distribution), and a U-shaped relationship can be inferred if the two lines have opposite, significant signs. Testing our hypothesis this way is preferable to the commonly-used quadratic regression approach, because the latter hinges on the assumption that the relationship between x and y is exactly quadratic, rather than just a change in sign. Simonsohn (2018) has shown that the use of quadratic regression for testing U-shaped hypotheses can lead to both false positive and false negative results.

Although meta-analyses only indicate small gender differences in school performance (Voyer & Voyer, 2014), we controlled for potential gender effects in all analyses, given the rather small number of female students. Dummy variables were created to control for potential differences between the three cohorts. We also investigated if having a side job had an effect on our outcomes variables. For the students who had provided this information, we found no differences in the Bachelor program between students holding vs. not holding a job for GPA; Pillai-Spur: $F(4, 255) = .36, p = .84$; or study duration; Pillai-Spur: $F(4, 255) = .97, p = .42$. Therefore, we did not control for this variable in our analyses.

Third, we inspected the role of APT while controlling for high school GPA, by calculating in a first step partial correlations (including also the control variables). Some of the subfacets of the NEO-PI-R are included in the calculation of more than one of the six APT, which leads to a rather high degree of interrelatedness of the tendencies, also with the Big Five traits. This hampers the investigation of their combined predictive value (e.g., in a multiple regression analysis). Therefore, to identify the relative importance of the tendencies with regard to the academic success criteria while taking into account the problem of multicollinearity, we performed relative weight analysis in R (Tonidandel & LeBreton, 2011) to test our hypotheses on the incremental validity of APT with respect to GPA and C (H3-

H4). To calculate the raw and rescaled relative weights (raw relative weight of each predictor divided by the R^2 of the full model), as well as statistical significance of the weights, we used the online tool provided by Tonidandel and LeBreton (2015). Based on 10.000 bootstrapping samples, we obtained confidence intervals to test for the significance of the raw weights.

Lastly (H5), the longitudinal data allowed us to examine the validities of APT over the course of the three-year study program and tested for differences by inspecting the 95% CI. We had to take into account the fact that 33.8% of the students dropped out of the program in the first year (cohort 2009: 31.5%; 2010: 31.7%; 2011: 38.3%), mainly due to a negative mandatory study advice. Therefore, we corrected for potential range restrictions (or in terms of personality also range enhancement) from Year 2 on, employing the approximation provided by Alexander, Carson, Alliger, and Carr (1987), as used in previous research (Lievens et al., 2009). The values used to correct for range restriction/enhancement in the predictor as well as the criterion due to attrition are displayed in Table A of the *Electronic Supplementary Material (ESM)*. We thus were able to obtain estimations of the operational validities (predictor-criterion relationship), as if there had not been range restriction in the sample, and therefore draw conclusions for admission and selection for the full student pool, and not only the ones remaining in the study program. Although attrition also occurred later in the study program, it was too small to warrant consideration.

Results

Table B in the ESM displays descriptive statistics, zero-order correlations, and reliabilities of the study variables. Due to the mandatory study advice, average grades and CP earned in the first year were lower than those obtained in the following years.

First, we tested the expected relationships of APT with academic success (H1) by inspecting the zero-order correlations ($p \leq .01$; see Tables 1-3, observed correlations). Three aberrant tendencies showed substantial relationships with academic success across the

Bachelor program with validities reaching (absolute) values up to .31. In line with H1c, the *antisocial* tendency was negatively related to GPA throughout the study years and in the overall program (validities ranging from -.20 to -.25). In addition, substantial relationships were found to persistence in terms of CP earned per year (exception: 3rd year) and to the number of months it took to earn the Bachelor diploma. In partial support of H1d, the *avoidant* tendency was positively related to overall GPA (.21). However, a significant relationship was only visible in the 1st academic year for grades (.14) and the avoidant tendency was not systematically related to study progress. In support of H1e, the *obsessive-compulsive* tendency showed a positive relationship to GPA (validities from .17 to .24) and study progress (absolute validity values up to .31). Unexpectedly, the narcissistic tendency correlated negatively with GPA in the 1st year (-.14), and with GPA in the Bachelor program (-.18), which disappeared when controlling for prior performance (see partial correlations).

Second, to investigate retention in the study program in detail, we compared characteristics of persisters vs. leavers after the 1st academic year. Table 4 shows the results of a MANCOVA (covariates: gender, cohort), with the mean values of persisters (n = 295) and students who left the program (n = 137). The biggest difference was visible with regard to pre-university grades: leavers were characterized by a lower high school GPA than persisters. Furthermore, significant differences on three APT were visible, with up to 6% explained variance. In line with our hypotheses, students who left the program scored higher on borderline (H1a) and antisocial (H1c), and lower on obsessive-compulsive tendencies (H1e). We again found no evidence for effects of schizotypal tendencies on academic success, so that we have to reject H1b.

Table C in the ESM shows the results of the two-lines approach to test for inverted U-shaped relationships between avoidant and obsessive-compulsive tendencies and academic success (H2). In none of the analyses did the results indicate contrasting (positive to negative)

regression weights ($p \leq .01$) for persons scoring low to moderate compared with those scoring moderate to high in the distribution of the two aberrant tendencies. Only linear relationship patterns were evident. To compare, we also conducted the more traditional approach to test for curvilinear effects by using quadratic product terms in a series of hierarchical regressions. In none of these analyses did the quadratic term reach a significant prediction weight ($p \leq .01$). Taken together, the results do not provide support for an inverted U-shape relation, but indicate linear effects mainly for low to moderate levels of the distribution of these tendencies. For moderate to high levels of the distributions, no (positive or negative) effects were visible.

A look at the partial correlation coefficients (Tables 1-3) of APT with academic success provides indication for the relevance of these tendencies independent of gender, cohort, and high school GPA. Three aberrant tendencies showed relationships with academic success throughout the study program independent of prior performance: *Borderline* and *schizotypal* tendencies were negatively related to CP earned in Year 1 (-.14), and higher *antisocial* characteristics were associated with lower grades in the Bachelor program (-.18). Independent of high school GPA, the *obsessive-compulsive* tendency was still positively related to academic success, and showed consistent significant relationships across all three academic years to academic success, almost in the value range of the zero-order correlations (absolute validity values up to .31). To test if aberrant tendencies show incremental validity above and beyond GPA (H3), we conducted relative weights analyses to obtain estimates of the contribution of each tendency to the prediction of the different academic success criteria (including cohort, gender, high school GPA as control variables and all six APT; Tables 1-3). Overall, GPA was predicted better (up to 46% of explained variance) than study progress (up to 35% of explained variance). This seems mainly due to the higher amount of variance explained by GPA (high school GPA was a highly significant predictor for GPA in each

prediction). The highest amount of variance was explained by the model variables for GPA in the 1st year ($R^2 = .46$), and the lowest for CP in the 3rd year ($R^2 = .08$). In particular, the *obsessive-compulsive* tendency seems to be an important predictor of academic success, supporting H3e. For GPA a significant relative weight was visible throughout the study program, with the percentage of sole contribution to the amount of explained variance varying between 5.6 and 11.7%. This tendency also contributed to the prediction of CP in the 1st year and to overall study duration (between 16.5 and 52% of the total model R^2 accounted for by this variable). With regard to the other APT, results of the relative weights analyses only partially supported H3 for borderline (H3a: significant relative weight for CP in the 3rd year) and antisocial tendencies (H3c: significant relative weights for GPA in the 1st, and CP in the 2nd year).

Table 5 shows the results of the hierarchical regression models testing for the incremental validity of APT above and beyond the control variables, GPA, and C for overall GPA and study duration in the BSc. program (H4). Adding C to the prediction led to a significant increase in explained variance for both GPA (2%) and study duration (7%). Adding the six APT in the final step, led to a significant improvement in explaining GPA ($\Delta R^2 = .03$, $p = .050$), but the additional amount of explained variance for study duration missed the significance level closely ($\Delta R^2 = .04$, $p = .052$). The results of the relative weight analyses showed that, when all predictors were included in the regression model, the antisocial tendency contributed to the prediction of GPA (partial support for H4c) and the obsessive-compulsive tendency contributed to the prediction of both GPA and study duration (support for H4e).

Inspecting the (operational) validities of APT with regard to academic success over time (cf. Tables 1-2), we found slight to modest increases on a descriptive level for all six APT with GPA across the three nominal study years, with the largest changes from the 1st to 3rd

year in validities for *antisocial* (from -.21 to -.32) and *obsessive-compulsive* (from .22 to .33) tendencies. With regard to study progress in terms of CP earned, on the descriptive level the *antisocial* tendency showed a slight increase in validity from the first (-.21) to the second year (-.27), but was unrelated to persistence in the third year. Unexpectedly, the obsessive-compulsive tendency showed a slight decrease on the descriptive level over the three years (from .29 to .21) for persistence. However, the inspection of the 95% CI of these correlation coefficients allowed no conclusion in terms of statistical difference, as all intervals showed substantial overlap (H5 rejected).

Discussion

To our knowledge, our study is the first to demonstrate the predictive validity of a broad range of APT for different indicators of academic success in higher education for a STEM study program. Building on the compound technique based on the FFM (Miller et al., 2005) that was previously used to predict career outcomes (Wille et al., 2013), we operationalized six APT and showed that these tendencies can be linked to academic achievement and persistence. Overall, the findings of our longitudinal study with three cohorts of Bachelor students support the validity of certain APT for GPA and study progress, also independent of known predictors in this field (high school GPA, C). However, we found only limited support for nonlinear relationships, and no clear signs of increasing validities over time throughout the study program.

In detail, our results across a three-year BSc. program support the validities for both antisocial and obsessive-compulsive tendencies, partly also independent of GPA and C. First, students scoring low on *antisocial* characteristics tend to obtain higher grades and complete their study faster than students scoring high on this dimension. This confirms prior findings on disorders based on personality pathology measures (King, 1998), and shows that antisocial tendencies operationalized by the FFM hamper academic success. This may be explained by

the impact of this tendency on problematic (self-regulatory) behavior in the academic context, such as problems in interpersonal functioning, or a tendency to cheat or procrastinate. Second, our results provide important insights into potentially beneficial effects of “maladaptive” traits in higher education. We found support that the *obsessive-compulsive* tendency are positively linked to academic success. A potential explanation may reside in motivational mediating effects with, for example, the aspect of (self-centered) perfectionism supporting academic achievement. Regarding the other APT, we found partial support for the expected negative effect of the *borderline* tendency on study progress and dropout, and a positive effect of the *avoidant* tendency on grades. Unexpectedly, we found some evidence for a negative effect of narcissism on objective performance indicators, whereas there does not seem to be a major (dis)advantage to scoring high on the schizotypal tendency for the kind of STEM students investigated in the current study.

This pattern of results is intriguing, as the APT that are associated with higher grades and faster completion of the study program are not necessarily those that prepare students properly for the future job market. Our results on a beneficial effect of the obsessive-compulsive tendency for academic success do seem to stand in contrast to findings of Wille et al. (2013), who found that this tendency is largely unrelated to career outcomes of college alumni. For the antisocial tendency, our findings point towards a negative effect on academic success, whereas in the work context Wille et al. (2013) found this tendency to be associated with a higher number of subordinates, or with working at the management level. Also for the avoidant tendency, different results in the academic and the work context are visible, as Wille et al. (2013) found this tendency to be negatively related to extrinsic (e.g., income) as well as intrinsic career outcomes (e.g., job satisfaction). However, our results suggest that students scoring high on avoidant characteristics may perform better (in terms of GPA).

Furthermore, our results confirm the relevance of distinguishing different indicators of academic success to capture the effects of APT. Building on the different components of academic success (York et al., 2015), we included multiple indicators of academic achievement and persistence. While the overall result pattern for APT only slightly varied with regard to GPA and study progress, some differences in the relationships were indeed visible. While antisocial and obsessive-compulsive tendencies were consistently related to both indicators of academic success, the avoidant tendency only showed substantial validities for grades, and the borderline tendency was only related to dropout in the first year. Overall, GPA was predicted better than study progress, and the incremental validity of APT was, in particular, visible for GPA. Especially later in the study program (year 3), study progress in terms of CP earned was hard to predict. This mainly seems to be due to the lower predictive validity of high school GPA, which is in line with the lower correlations found for GPA and retention (Robbins et al., 2004). However, the lower (absolute) amount of variance explained suggests that also other variables than the ones studied here impact study progress. For example, theoretical models of educational persistence (see Robbins et al., 2004) highlight also the role of other background factors or behavioral variables (e.g., socioeconomic status, integration into the academic system).

Overall, we found no evidence of an inverted U-shaped relation of APT with academic success. However, our results still point towards non-linear relationships, as we found linear relationships of avoidant and obsessive-compulsive tendencies with academic success for low to moderate levels, but no relationship (neither positive nor negative) for moderate to high values of these tendencies. Although in the educational context a few studies point towards quadratic relationships for general personality traits on performance (e.g., Cucina & Vasilopoulos, 2005), overall the empirical findings regarding such personality effects seem inconsistent (e.g., Benson & Campbell, 2007; Converse & Oswald, 2014), and if identified

effects seem rather small (Whetzel, McDaniel, Yost, & Kim, 2010). Our findings seem more in line with reported evidence for a plateau effect in the recent literature for other life outcomes such as health (e.g., Nickel, Roberts, & Chernyshenko, 2019). While research findings point towards particular conditions in which nonlinear effects might occur, such as high or low organizational support (Uppal, 2017), more theoretical and empirical work seems necessary to specify the particular benefits and costs that might explain the nature of such effects (Busse et al., 2016), especially in the academic context.

In sum, our results demonstrate the relevance of APT above the key predictors in this field and sustain also a positive role of (some) aberrant tendencies in the academic setting. We demonstrated that independent of high school GPA, which was also the best predictor of academic achievement in our study, especially the obsessive-compulsive tendency was positively related to study outcomes and accounted for a significant amount of variance in the prediction of study success in the relative weight analyses. Although the relationships partly disappeared for other aberrant tendencies when controlling for high school GPA, we cannot rule out indirect effects (see correlations of APT with high school GPA, Table A in ESM). Furthermore, incremental validity was evident for the obsessive-compulsive tendency when controlling for C, which is intriguing given that all facets of C go into the conceptualization of this tendency based on the FFM. However, although C has demonstrated large relationships with the obsessive-compulsive personality disorder, also other subfacets, for example, of Neuroticism, Extraversion, and Openness have been identified as essential for describing this personality disorder (Mike et al., 2018; Samuel, Riddell, Lynam, Miller, & Widiger, 2012).

Furthermore, we found no clear evidence for increasing validities of APT over the three-year study program, besides small (descriptive) changes in the predictive validity of antisocial and obsessive-compulsive tendencies with regard to GPA across the BA program. Therefore, our results seem more in line with recent findings on the changeability of the

validities of global compared to specific traits (Harari, Naemi, & Viswesvaran, 2019). Our results suggest that APT predict success throughout an (undergraduate) engineering study program in terms of “getting ahead” (e.g., obsessive-compulsive), as well as “getting along” (e.g., antisocial) (Hogan & Holland, 2003). Although these characteristics have been linked to dysfunctional interpersonal strategies (Knights & Kennedy, 2007), we found evidence for positive and negative effects for APT.

Limitations and future research directions

Although we were able to investigate the effect of APT on objective performance indicators in a longitudinal design in a group of students enrolled in the same undergraduate program, we have to acknowledge several limitations of our study. First, we were not able to investigate the predictive validity of APT in an even longer time frame (e.g., in graduate programs), although prior research suggests that changes in the importance of such factors may occur at a later stage of the study program (Lievens et al., 2009). Second, while we corrected for range restriction/enhancement, we did not correct for other potential shortcomings (such as unreliability of predictor and criterion), so that our obtained relationship may actually form the lower limit of the real relationships of APT with academic success. Third, it is not clear yet which mediating variables explain the relationships found. Future studies should, therefore, investigate more comprehensively how APT are related to, for example, various self-regulatory or motivational strategies in the academic context (e.g., academic self-efficacy, goals, affect, cognitions) (e.g., Brown, Tramayne, Hoxha, Telander, Fan & Lent, 2008; Pintrich, 2000; Richardson et al., 2012) or which variables function as mediators for the APT effects on the different indicators of academic success. Fourth, we only investigated potential nonlinear effects in terms of (inverted) U-shaped relationship although some authors have suggested that there might be cubic relationships of personality factors to performance (e.g., Whetzel et al., 2010). While we ensured a high response rate of in total

94% of students of the three cohorts, participation in the study was not mandatory. The response rate for leavers was lower (88%) than for students who persisted (97%), so that our results might not comprehensively cover characteristics of all leavers. Furthermore, there might be different reasons for dropping out from the program in the first year, not only the lack of success but also misfit with the program, lack of interest, or expectations not being met, which might also be linked to specific APT. Finally, the mandatory study advice led to a forced dropout based on a lack of study progress, which may form a highly demanding situation in the first year that may mask the effects of (certain) personality traits.

Relevance/contribution

To our knowledge, our study is the first to longitudinally investigate the effect of six broad APT in the academic field and provide evidence for the long-term effects of these FFM-compound traits. Given the problem of high dropout at technical universities and the essential relationships of some of the aberrant tendencies with academic performance, our findings have important implications for admission and counseling procedures at technical universities. In addition to pre-university performance, our results suggest that it is essential to take also non-cognitive predictors of academic success into account. It seems useful in the academic setting to use the compound technique based on the FFM to obtain additional information on multiple APT to identify students with an increased risk of developing performance problems, to ensure long-term success of students in such programs. For example, such a screening may be used to ideally target interventions to enhance students' performance in STEM programs (e.g., via goal setting interventions, Richardson et al., 2012) for specific student groups (scoring high or low on certain aberrant personality tendencies).

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Table 1:

Validities and relative weight analysis for aberrant personality tendencies and academic achievement in the 1st academic year

	GPA				CP			
	Observed correlation	Partial correlation	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)	Zero-order correlation	Partial correlation	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)
Year 1 (N = 432)	Dependent Variable = GPA				Dependent Variable = CP			
	Year 1 (total R ² = .46)				Year 1 (total R ² = .35)			
Controls + GPA			.410	88.70			.257	73.2
Schizotypal	.08	-.01	.004	1.0	.01	-.07	.003	1.0
Avoidant	.14**	.06	.003	0.8	.09	.01	.005	1.4
Borderline	-.09	-.07	.003	0.6	-.15**	-.14**	.008	2.3
Antisocial	-.21**	-.11*	.009*	1.9	-.21**	-.14**	.011	3.3.
Narcissistic	-.14**	-.06	.006	1.4	-.13**	-.07	.008	2.3
Obsessive-compulsive	.22**	.17**	.026**	5.6	.29**	.26**	.058**	16.5

Notes. GPA= Grade Point Average; CP = number of credit points earned in the academic year. Partial correlations include controls (cohort, gender) and high school GPA. Raw and rescaled relative weights of the control variables were summed. Relative weights significance levels based on 10,000 bootstrap replications. * $p < .05$, ** $p < .01$.

Table 2:

Validities and relative weight analysis for aberrant personality tendencies and academic achievement in the 2nd and 3rd academic year

	GPA					CP				
	Observed correlati ons	Operation al validities	Partial correlatio n	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)	Observed correlati ons	Operation al validities	Partial correlatio n	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)
Year 2 (N = 285)	Dependent Variable = GPA Year 2					Dependent Variable = CP Year 2				
	(R ² = .29; with controls)					(R ² = .16; with controls)				
Controls + GPA				.242	83.6				.116	72.6
Schizotypal	.05	.08	.00	.002	0.7	-.02	-.03	-.04	.000	0.5
Avoidant	.14*	.22	.11	.006	1.9	.06	.10	.04	.002	1.5
Borderline	-.02	-.03	-.03	.002	0.8	-.08	-.13	-.08	.001	1.2
Antisocial	-.20**	-.31	-.15*	.011	3.7	-.17**	-.27	-.15*	.011	6.7
Narcissistic	-.15*	-.22	-.10	.008	2.8	-.12*	-.18	-.10	.007	4.7
Obsessive-compulsive	.17**	.27	.17**	.002*	6.5	.18**	.29	.17**	.021	12.9

Table 2 continued

Dependent Variable = GPA Year 3					Dependent Variable = CP Year 3					
Year 3 (N = 276)					(R ² = .28; with controls)				(R ² = .08; with controls)	
Controls + GPA					.220	79.4			.041	37.5
Schizotypal	.02	.03	-.06	.003	1.1	-.11	-.13	-.11	.009	10.5
Avoidant	.14*	.22	.08	.007	2.5	.02	.02	.00	.003	4.1
Borderline	-.09	-.13	-.09	.003	1.0	-.08	-.09	-.12*	.004	4.6
Antisocial	-.21**	-.32	-.13*	.008	3.1	-.10	-.12	-.07	.003	3.1
Narcissistic	-.15*	-.22	.08	.007	2.7	-.07	-.08	-.03	.002	2.2
Obsessive-compulsive	.22**	.33	.20**	.029*	10.4	.18**	.21	.18**	.023	26.9

Notes. GPA= Grade Point Average; CP = number of credit points earned in the academic year. Partial correlations include controls (cohort, gender) and high school GPA. Operational validities = corrected for range restriction / enhancement in predictor and criterion – *u* values used for corrections see ESM Table A. Raw and rescaled relative weights of the control variables were summed. Relative weights significance levels based on 10,000 bootstrap replications. * $p < .05$, ** $p < .01$.

Table 3:

Validities and relative weight analysis for aberrant personality tendencies and academic achievement in the full BSc. study program

	GPA					Study duration (in months)			
	Observed correlations	Operational validities	Partial correlation	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)	Observed correlations	Partial correlation	Raw relative weights (RW)	Rescaled relative weights (RS-RW %)
BSc program (N = 270)	Dependent Variable = GPA (R ² = .36; with controls)					Dependent Variable = study duration in months (R ² = .16; with controls)			
Controls + GPA				.269	75.3			.050	30.7
Schizotypal	.10	.27	.02	.005	1.5	.06	.08	.003	2.1
Avoidant	.21**	.50	.14*	.009	2.5	-.09	-.07	.005	2.9
Borderline	-.02	-.06	-.03	.003	1.1	.06	.08	.005	3.0
Antisocial	-.25**	-.55	-.18**	.015	4.3	.18**	.15*	.010	6.3
Narcissistic	-.18**	-.43	-.10	.013	3.6	.09	.06	.005	3.0
Obsessive-compulsive	.24**	.54	.24**	.042**	11.7	-.31**	-.32**	.084**	52.0

Notes. GPA= Grade Point Average; CP = number of credit points earned in the academic year. Partial correlations include controls (cohort, gender) and high school GPA. Operational validities = corrected for range restriction / enhancement in predictor and criterion – *u* values used for corrections see ESM Table A. Raw and rescaled relative weights of the control variables were summed. Relative weights significance levels based on 10,000 bootstrap replications. * $p < .05$, ** $p < .01$.

Table 4:

Predicting attrition: comparison among persisters and leavers on school GPA and aberrant personality tendencies in the 1st study year

	Persisters		Leavers		MANCOVA		
	(n = 295; response: 97%)		(n = 137, response: 88%)				
	M	SD	M	SD	F(1, 427)	p	Eta ²
GPA School	6.99	.53	6.54	.38	71.40	< .001	.14
Schizotypal	114.91	16.87	114.54	16.45	.02	.900	.00
Avoidant	162.57	22.60	159.61	24.55	.95	.329	.00
Borderline	180.91	20.73	187.88	21.47	12.73	< .001	.03
Antisocial	303.64	31.18	314.06	33.27	8.76	.003	.02
Narcissistic	221.28	25.61	224.32	23.97	.93	.335	.00
Obsessive-compulsive	268.64	23.82	255.98	22.82	25.69	< .001	.06

Notes. Although 295 students were still enrolled in the beginning of the second study year, 10 of them dropped out during the second academic year. Covariates used in the MANCOVA: Cohort, gender.

Table 5:

Incremental validities obtained (ΔR^2) from hierarchical regression models including controls (Step 1), Conscientiousness (step 2), and aberrant tendencies (Step 3, including rescaled relative weights analyses results) to predict academic achievement in the full Bachelor program

	GPA		Study duration	
	ΔR^2	Rescaled relative weights	ΔR^2	Rescaled relative weights
Step 1: Controls + GPA	.30**	74.59%	.05**	29.95%
Step 2: Conscientiousness	.02**	5.17%	.07**	12.36%
Step 3: FFM Aberrant tendencies	.03*		.04+	
Schizotypal		1.54%		1.72%
Avoidant		2.79%		3.00%
Borderline		0.95%		2.67%
Antisocial		3.74%		5.37%
Narcissistic		3.45%		2.95%
Obsessive-compulsive		7.76%		41.96%
Total Model R^2 (Step 3)	.36**		.16**	

Notes. N = 270. Step 1: Control variables (cohort, gender) + high school GPA. Results

aggregated. Significant raw relative weights rescaled weights are printed bold. + $p < .10$ * $p < .05$. ** $p < .01$.