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Abstract

Gifted education needs to be constantly improved and differentiated for various types of domain-specific giftedness, especially in STEM (science, technology, engineering, and mathematics) subjects. Therefore, teachers must be adequately trained in the field of giftedness. The aim of this study was to investigate (the Big Five) personality factors in scientifically gifted and nongifted students to find potential educational adjustments that should be considered during teacher trainings. The sample consisted of N = 372 students between 4th and 7th grade (mean age = 10.62 years, 38.7% female). Scientifically gifted students showed higher scores for Openness and lower scores for Agreeableness than nongifted students. This study provides initial findings about the personality of scientifically gifted students and supports that they should be promoted through problem and action-orientated teaching. More differentiated methods should be used in further research to substantiate the presented tendencies.

Introduction

In October 2020, the German STEM (Science, Technology, Engineering, and Mathematics) sector still had 193,500 vacant positions (Angerer et al., 2020). To counteract the lack of skilled workers, the National Association for Gifted Children (NAGC) (2015) proposed to focus on scientifically gifted school students. If gifted education in science is improved, scientifically gifted students may be more motivated to pursue a professional career in the STEM sector. However, to accomplish this, teachers must be adequately trained to identify and teach scientifically gifted students. Educational concepts should then be adjusted for scientific gifted promotion, for students to reach their full potential and exceed school standards (Angerer et al., 2020; NAGC, 2015). According to International Panel of Experts for Gifted Education (iPEGE) (2009), a successful gifted education program and the promotion of giftedness in school must comprehensively develop gifted students' personality. To do so, educators must be made aware of gifted students' characteristics and needs, and how they may differ from nongifted students within the same school subject (Van Tassel-Baska, 2005). The term nongifted is used to name participants who are not diagnosed as gifted, according to the respective study's criteria. Further research needs to explore unique characteristics of these domain-specific gifted students to implement them in teacher training and advance gifted education in science.

Scientific Giftedness and Promotion

Various assumptions about defining intellectual giftedness measured by an IQ test make it difficult to develop standardized promotional designs. As a multifaceted concept, it has been suggested to investigate domain-specific conceptions of giftedness, which seem to deliver a promising approach for talent development in- and outside school (iPEGE, 2014; Olszewski-Kubilius & Thomson, 2015). Many publications about domain-specific gifted education deal with STEM subjects, but only evaluate STEM schools and programs, STEM career choices, and STEM talent development (Ambrose, 2021; for a review, see Ulger & Çepni, 2020). Although this provides helpful information about the practicality of certain didactical designs and methods, concrete conceptions about scientific giftedness remain underrepresented (Ulger & Çepni, 2020). It has been accepted that it is inaccurate to measure learning potential and performance capability without measuring non-cognitive characteristics such as motivation, interest, discipline, self-confidence, and self-monitoring skills (iPEGE, 2009; Renzulli, 1999). In the Munich longitudinal study of giftedness, seven relatively independent ability groups (predictors) and various performance domains (criterion variables), as well as personality (e.g., motivational) and social environmental factors (Heller et al., 2005) were identified to define giftedness. Accordingly, individual's intellectual abilities are just one of several talent factors acting as predictors to express giftedness. Creative abilities, social competence and practical intelligence must be considered as well.

Furthermore, non-cognitive personality characteristics, such as the ability to cope with stress or achievement motivation, and environmental conditions, like the home or classroom atmosphere, also affect giftedness (Heller et al., 2005). Following these assumptions, modern conceptions of giftedness distance themselves from a simple IQ score when it comes to diagnostics and define an interaction of the factors that lead to outstanding achievement in specific domains. Models like these provide approaches to explore how domain-specific giftedness could be structured and diagnosed. George (2012) expects scientifically gifted students to have unique characteristics and show higher performances in STEM subjects than their classmates. However, it is still questionable which aspects are crucial (Ulger & Çepni, 2020). Recent studies attribute scientifically gifted students as problem finders and solvers, who are curious for the natural sciences and have an intrinsic motivation to explore its phenomena (Karnes & Riley, 2005). Gifted students in STEM are described to have even more differentiated abilities than gifted students in other domains (Sternberg & Davidson, 2005). Wegner (2014) developed a model of scientific giftedness (see Figure 1) which may serve as an acceptable framework. It is postulated that the manifestation of scientific giftedness results from a complex interplay of factors such as self-confidence, work discipline, high levels of creativity, intelligence, social competence, self-monitoring, and high scientific interest (Wegner, 2014). Complementary to general intellectual ability, special characteristics and needs must be considered to identify a domain specific giftedness (Van Tassel-Baska, 2005). Furthermore, giftedness in science is seen to express itself in skills such as quickly retaining biological facts, the ability to combine abstract and phenomenological information, and the interdisciplinary application of knowledge in STEM (Wegner & Schmiedebach, 2017). Sternberg (2018, 2019) believes that examining skills when conducting scientific work is important to identify gifted students. He states theses skills as generating hypotheses, generating experiments, drawing conclusions, reviewing, editing, and evaluating teaching.

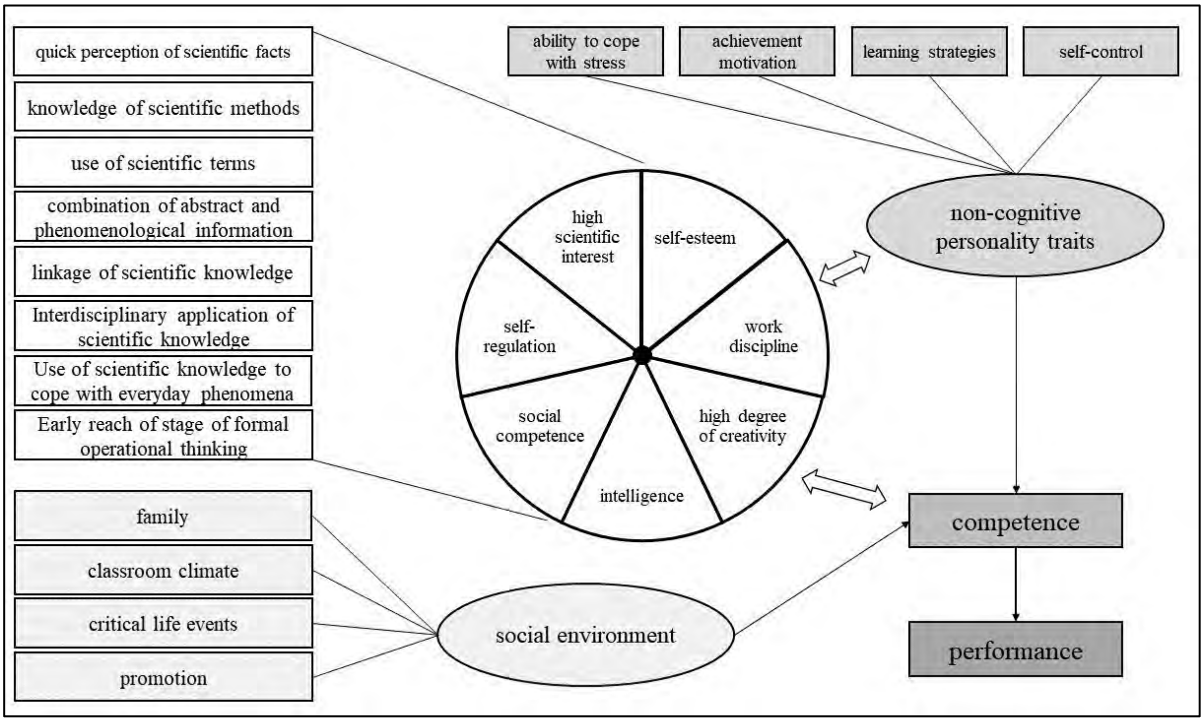

Figure 1. Conception of Scientific Giftedness according to Wegner (2014)

Additionally, Wegner (2014) adapted his model to include potential social environmental influences (Heller et al., 2005; see Figure 1). Social environment can be subdivided into the classroom climate, family environment, critical life events, and promotion. Even though research in these areas, on intellectual giftedness exists (e.g., Lüftenegger et al., 2015; Olszewski-Kubilius et al. 2014; Peterson et al., 2009; Rita & Martin-Dunlop, 2011), investigations about them in scientific giftedness are still missing. There is a common approach to promote scientifically gifted students (Ulger & Çepni, 2020). It is about offering immersive STEM educational activities like experiencing actual scientific work (e.g., Olszewski-Kubilius, 2009; Olszewski-Kubilius & Thompson, 2015). This category includes the theory of inquiry-based learning (e.g., Bell et al., 2010). As a problem-based approach, it is seen as highly effective in scientific gifted education (Van Tassel-Baska, 2013; Wegner & Fischer, 2013). Pedaste et al. (2015) analyzed existing literature and identified 5 main phases for inquiry-based learning: orientation, conceptualization, investigation, conclusion, and discussion. In the course of STEM gifted promotion, it is recommended to observe a scientific phenomenon or problem to introduce a new topic (orientation; Wegner & Fischer, 2013). Based on that, hypotheses are formulated, and students plan their own individual solutions and associated experiments (conceptualization), which they carry out, record, and evaluate (investigation). Subsequently, their methods and results are analyzed and written up (conclusion) to share their work with fellow classmates (discussion; Bell et al., 2010; Pedaste et al., 2015). To further develop promotional concepts like this and improve current curriculums, teachers need to know more about the personality of gifted STEM students (Van Tassel-Baska, 2005).

Scientific Giftedness and Personality

The iPEGE (2009) points out that investigating adolescent personality and behavior can provide useful indications to successfully promote and support gifted students, opening up a field of research to look at extending and improving current methods of teacher training (Baudson & Preckel, 2013; iPEGE, 2009; Neyer & Asendorpf, 2018). Several decades ago, researchers postulated that there could be strong correlations between giftedness and psychological abnormities (Rost, 1993). Many studies claimed that intellectually gifted students were more likely to struggle with emotional issues and display behavioral, psychosocial, and emotional problems, which has been labelled as the disharmony theory (Gallagher, 1990; Gross, 1994; Neihart, 1999). In contrast, modern studies support the harmony theory, which assumes that gifted individuals are equally or better equipped with social-emotional aspects (Plucker & Callahan, 2008; Sternberg & Davidson, 2005). Both theories assume that gifted individuals have a high performance potential due to their increased intellectual capabilities (Baudson, 2016). As a majority of giftedness research has been based on the disharmony theory, stereotypes of gifted individuals have emerged within our society and are reinforced through television and other media (Baudson, 2016; Freund-Braier, 2009). Baudson and Preckel (2013) investigated the extent to which teachers agree with such stereotypes, leading them to conclude that gifted students might be more open towards experiences, but at the same time are more introverted, emotionally unstable, and less compatible when compared to nongifted students. Gaps in the existing research about certain characteristics of gifted students can influence a teacher's way of teaching, leading to ineffective domain-specific promotion. Teacher trainings should aim to make teachers aware about gifted students' needs and capabilities (Baudson & Preckel, 2013).

The Big-Five model is one of the most well-known models for describing individual personalities (McCrae & John, 1992). It consists of the factors Neuroticism (emotional stability), Extraversion (sociability, activity), Openness (range of interests, imaginative), Agreeableness (altruistic behavior), as well as Conscientiousness (self-organization skills, sense of responsibility), which individually vary along a continuum (Digman, 1990; Goldberg, 1981; McCrae & Costa, 2008; see Figure 2).

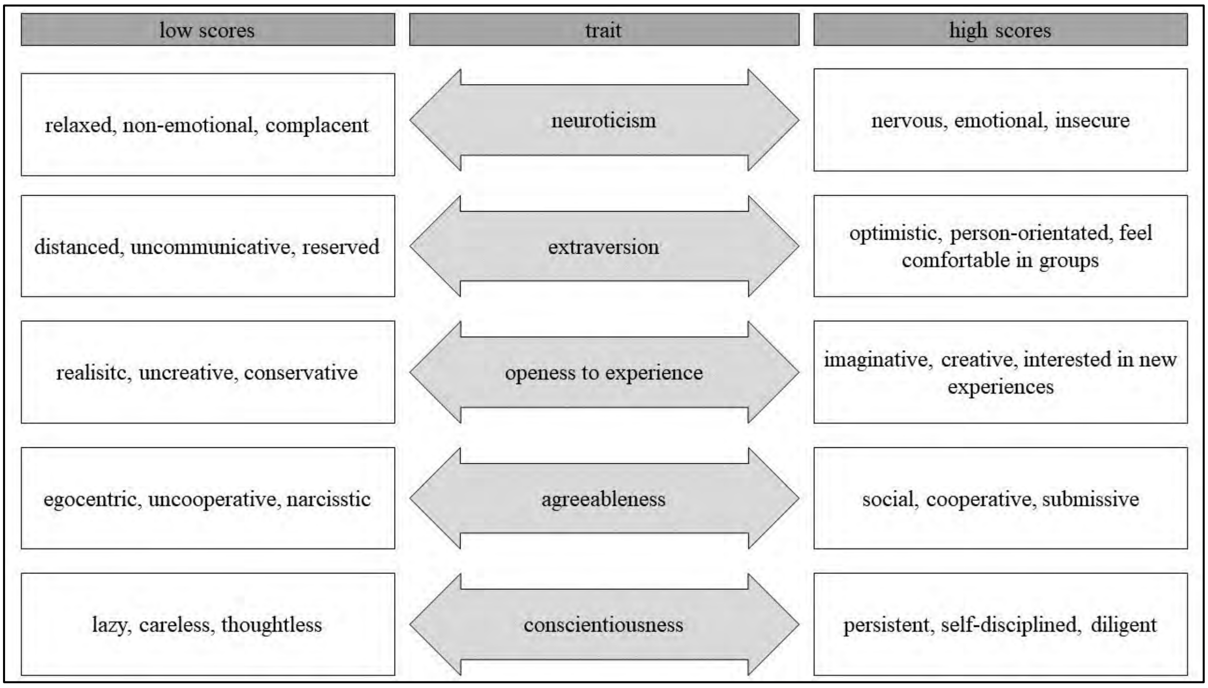

Figure 2. Describing Adjectives for Big-Five Personality Traits (adapted from McCrae & Costa, 2008)

Several personality studies have shown a correlation between giftedness and these factors (Ackerman & Heggestad, 1997; DeYoung, 2011; Mammadov et al., 2018; McCrae et al., 2002; Poropat, 2009), commonly finding that compared to nongifted students, gifted students score both significantly lower for Neuroticism and higher for Openness (Dimitrijević, 2012; Freund-Braier, 2009; Hampson, 2006; Kalashi et al., 2018; Limont et al., 2014; Wirthwein et al., 2019; Zeidner & Shani-Zinovich, 2011). No significant differences in gifted and nongifted students' scores for Extraversion, Agreeableness, and Conscientiousness have been found. All these studies defined giftedness as a measured IQ score, which hardly allows any predictions to be made for scientifically gifted students. Sternberg (2018) points out that the cognitive skills needed to be successful in STEM and perform high quality scientific work cannot be measured through simple IQ tests. "Analytical intelligence for relatively abstract kinds of problems is largely distinct from the practical intelligence that applies cognitive skills to particular domains of practice" (Sternberg, 2018, p. 79).

Findings that gifted students have lower Neuroticism (Limont et al., 2014; Zeidner & Shani-Zinovich, 2011) might possibly be observed in scientifically gifted students as well, due to a higher self-concept (Peperkorn & Wegner, 2021, submitted for publication). There are no findings which indicate that there are significant differences in Extraversion between intellectual gifted and nongifted students (Peperkorn & Wegner, 2020). However, differences might be observed in Extraversion, because scientific work includes presentations and open discussions (Bell et al., 2010), which require a certain degree of being extraverted. It also seems plausible that scientifically gifted students show higher scores for Openness because of their assumed high interests in science. However, on the other hand scores might be lower here because students focus on STEM and neglect other subjects. Although an inquiry-based approach requires social competency to successfully work with others, other areas such as mathematics is comprised of individual work. Therefore, the importance of Agreeableness for scientific giftedness is unclear. As giftedness is influenced by factors like work-discipline, self-regulation, and self-control (e.g., Heller et al., 2005; Wegner, 2014), it seems plausible that scientifically gifted students show higher values for Conscientiousness than nongifted students regarding actual scientific work.

All existing studies about gifted students' personality refer to a general concept of giftedness. As a result, there is a considerable lack of comparable studies that measure domain-specific giftedness, beyond intelligence as a factor for cohort assignment (Peperkorn & Wegner, 2020). Hardly any other studies used alternative measures, such as school performance, domain-specific intelligence tests or direct measures of domain-specific skills (Sternberg, 2018).

Study Objectives

The lack of qualified professionals in the STEM sector (Angerer et al., 2020) can possibly be countered by improving teacher training to identify and promote scientifically gifted students (NAGC, 2015). Educational programs and specific curriculums for scientifically gifted students should consider potential unique characteristics and personality factors (iPEGE, 2014; Van Tassel-Baska, 2005). However, these aspects remain largely unexplored, especially in the field of domain-specific giftedness. This study aims to close the gap in existing research by exploring scientifically gifted students' personalities using the five-factor model (Digman, 1990; Goldberg, 1981; McCrae & Costa, 2008). We hypothesize:

H1: Scientifically gifted students score significantly different values for the factor Neuroticism compared to scientifically nongifted students.

H2: Scientifically gifted students score significantly different values for the factor Extraversion compared to scientifically nongifted students.

H3: Scientifically gifted students score significantly different values for the factor Openness compared to nongifted students.

H4: Scientifically gifted students score significantly different values for the factor Agreeableness compared to nongifted students.

H5: Scientifically gifted students score significantly different values for the factor Conscientiousness compared to nongifted students.

Furthermore, there are no studies which examine gender differences or grade level effects in scientifically gifted students' personalities. We further hypothesize:

H6: There are significant gender differences in personality traits, based on the five-factor model.

H7: There is a significant effect for grade level on personality of scientifically gifted students, based on the five-factor model.

Method

Participants

The sample consisted of a total 384 students between 4th and 7th grade (mean age = 10.63 years, 38.7% female, 59.8% attended Gymnasium, 1% attended Realschule, 39.2% attended elementary school). Possible scientific giftedness was determined by cooperating schools, based on marks and test scores in the school subject biology. Potential participants were further tested using the KFT4-12 + R (tested for intellectual performance in the areas quantitative/numeric skills (Q), and figurative thinking (N); Heller & Perleth, 2000) to examine an intelligence profile associated with scientific giftedness. Nominated students who refused to take the test were removed from the study. Students who met both criteria were identified as scientifically gifted (n = 175, 32.6% female, 50.9% attended Gymnasium, 2.3% attended Realschule, 46.3% attended elementary schools). Students from the sample who were not nominated by their schools as scientifically gifted were defined as nongifted (n = 209, 43.5% female, 67% attended Gymnasium, 33% attended elementary school).

Instrument

Students completed the NEO-FFI-30 (Körner et al., 2008) questionnaire either on a computer or using a pen and paper test. The NEO-FFI-30 is a shortened, German version of the NEO-FFI (Costa & McCrae, 1989). The wording of some items was adapted to the present age group to ensure reliability (Markey et al., 2002). The self-assessment sheet consisted of 30 items to examine the personality traits listed in the five-factor model, of which

6 items each are assigned to each of the factors: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. Items were rated using a five-point Likert-scale ranging from does not apply at all to fully applies and comparisons were made between the average sums of the individual factors (see Appendix for adapted and some sample items of the used questionnaire).

Legal and Ethical Aspects

All students participated on a voluntary basis and only participated if their parents gave informed consent. Data were obtained pseudonymized by using codes. Students were further informed that they could drop out of the study at any point. Governmental consent was not required in the state that this study was conducted.

Results

Internal Consistency

Internal consistency was separately evaluated by Cronbach's α for all personality factors and further separated into both cohorts (see Table 1). After removing three items ("I don't like to waste my time daydreaming / fantasizing."; "Poems impress me little or not at all."; "I never seem to be able to get organized."), we examined acceptable values (> 0.6) for all factors except for Extraversion (> 0.5) were the sample shows questionable values. Further differentiation between the two cohorts showed acceptable values for all factors within the nongifted cohort. Within the gifted cohort the values for the factors Neuroticism, Agreeableness and Conscientiousness were acceptable, but the factor Extraversion showed questionable values and Openness even unacceptable values (< 0.5; Kline, 2000; see Table 1).

Group Comparisons

To examine the effects of scientific giftedness, sex, and grade level a 2 x 2 x 4 (giftedness by sex by grade level) MANOVA (multivariate analysis of variance) was conducted. It showed a statistically significant main effect for scientific giftedness [Wilk's $\Lambda = .60$, $F(5, 365) = 49.27$, $p < .001$, partial n2 = .40] and grade level [Wilk's $\Lambda = .93$, $F(15, 1008) = 1.87$, $p = .023$, partial n2 = .03] on all five factors of personality. There was a significant interaction effect for scientific giftedness and grade level [Wilk's $\Lambda = .92$, $F(15, 1008) = 2.00$, $p = .013$, partial n2 = .03]. To further examine the effects of scientific giftedness, post-hoc univariate ANOVAs were conducted to look at scientific giftedness and grade level for every factor.

Table 1. Internal Consistency (Cronbach's α) for the Hole Sample, Gifted, and Nongifted Cohort

Big Five	Sample	Gifted	Nongifted
Neuroticism	.70	.64	.74
Extraversion	.55	.51	.60
Openness	.62	.41	.66
Agreeableness	.79	.67	.65
Conscientiousness	.69	.71	.66

A Bonferroni correction set the significance level to $p < .05 / 5 = .01$. Compared to nongifted students, gifted students tended to score lower for the factors Neuroticism and Extraversion, however these differences were not significant (rejects Hypotheses 1 and 2). Scientifically gifted students scored significantly higher for Openness (supports Hypothesis 3) and significantly lower for Agreeableness (supports Hypothesis 4; see Table 2).

Table 2. Means (M), Standard Deviations (SD), and Group Differences between Scientifically Gifted and Nongifted Students in Big Five Personality Traits.

Big Five	Gifted		Nongifted		$F_{(5, 355)}$	p	n^2
	M	SD	M	SD			
Neuroticism	16.19	4.11	17.01	4.60	1.32	.25	< 0.01
Extraversion	22.08	3.90	22.51	3.99	0.28	.60	< 0.01
Openness	20.25	3.83	17.05	4.92	19.53	< .001	0.05
Agreeableness	15.25	4.48	23.21	3.90	206.21	< .001	0.36
Conscientiousness	23.98	4.04	22.28	4.09	2.22	.137	< 0.01

For Conscientiousness, scientifically gifted students tended to show lower values than nongifted students, but no significant differences were found (rejects Hypothesis 5). Since sex had no main effect on the five factors [Wilk's $\Lambda = .98$, $F (5, 365) = 1.50$, $p = .189$, partial n2 = .02] and did not significantly interact with scientific giftedness [Wilk's $\Lambda = .92$, $F (5, 364) = .79$, $p = .556$, partial n2 = .01], we rejected Hypothesis 6. Significant grade level effects were observed only for Openness, $F (3, 368) = 5.84$, $p = .001$, partial n2 = .05. Post-hoc analysis revealed that the mean level of Openness decreased from 4th to 7th grade (-4.27, 95% CL [5.75, 2.80]), from 5th to 7th grade (-4.04, 95% CL [5.95, 2.13]), and from 6th to 7th grade (-3.38, 95% CL [5.02, 1.75]).

Taking the main interaction effect between scientific giftedness and grade level into account, post-hoc tests only revealed a significant interaction effect for the factor Agreeableness between scientific giftedness and grade level, $F (3, 369) = 6.46$, $p < .001$, partial n2 = .01. To explore possible effects of grade level on scientifically gifted students' values for Agreeableness, a multivariate ANOVA for the scientifically gifted cohort (alpha = .01) was conducted. No significant effects of grade level were observed on Agreeableness for the cohort of scientifically gifted students, $F (3, 171) = 2.01$, $p = .114$, partial n2 = .03, rejecting Hypothesis 7.

Discussion

The present study aimed to compare scientifically gifted and nongifted students' personalities based on the five-factor model (Digman, 1990; Goldberg, 1981; McCrae & Costa, 2008). Our results provide information to help develop the concept of domain-specific scientific giftedness and offer insight about potential personality characteristics of scientifically gifted students.

Limitations

There are certain limitations which must be considered when interpreting our results. Opposed to many other studies in the field of giftedness research, the intelligence quotient was not used exclusively used to define scientific giftedness (Warne, 2016). Scientific giftedness was based on previous approaches in which giftedness is regarded as an interplay between multiple factors (George, 1997; Karnes & Riley, 2005; Sternberg & Davidson, 2005; Sternberg, 2018; Wegner, 2014). To take these factors into account, we used nominations by schools as one step of our identification process. In other words, teachers were involved in our recruitment process. This harbors the risk that our results simply reflect stereotypes as to what teachers think scientifically gifted students are likely to be. Even if the nominations were based on marks and test scores, full objectivity cannot be guaranteed.

Resulting from the nomination process, the proportion of students in each school type is different between the gifted and nongifted cohorts. Gifted underachievers could have been underrepresented as they are less likely to attend a Gymnasium (Sparfeldt et al., 2006) and existing underachievers may not have been considered in the nomination process due to lower marks or test scores. Additionally, sample sizes from different grades varied greatly; this further reduces the power to measure grade level effects. Furthermore, the gender distribution between the gifted and nongifted cohort is unequal, which can be attributed to the nomination process of the gifted cohort. Results show no gender effects within the comparison groups, but regarding previous results possible differences between scientifically gifted girls and boys cannot be excluded (for a review, see Olszewski-Kubilius, 1988; Preckel et al., 2008). Finally, the study does not provide a valid way to further subdivide the group of nongifted students; these students may have had other talents that were not directly measured here. There are further limitations with our test instrument. Despite adjusting the wording of selected items and offering trained research assistants to help linguistic comprehension problems, the internal consistency (Cronbach's alpha) for Extraversion and Openness remains questionable respectively unacceptable for the gifted cohort (see Table 1). We still consider our results interpretable because inter-item correlations were still in an acceptable range for a broad personality constructs like Extraversion or Openness (0.1 – 0.2; Clark & Watson, 1995). There is an ongoing debate if and to what extent there are correlations between personality and language comprehension, particularly language development (e.g., Coplan & Weeks, 2009; Slomkowski et al., 1992; Smith Watts et al., 2014; Usai et al., 2009; but see Tõugu & Tulviste, 2017). Therefore, differences in linguistic understanding cannot be completely excluded but were minimized using research assistants during the survey.

Differences between Scientifically Gifted and Nongifted Students

To the best of our knowledge, this is the first study to examine the Big Five personality factors in scientifically gifted students. Previous studies found that gifted students scored significantly higher for Openness and lower for Neuroticism, but all defined giftedness as a certain IQ score (Peperkorn & Wegner, 2020). Since there are no studies that compare scientifically gifted and scientifically nongifted students, possible differences in all five personality factors were investigated. Based on the described assumption about scientific giftedness (George, 1997; Karnes & Riley, 2005; Sternberg & Davidson, 2005; Sternberg, 2018; Wegner, 2014) we concluded that there may be differences in Neuroticism. Contrary to studies on intellectual giftedness (Limont et al., 2014; Zeidner & Shani-Zinovich, 2011), we did not obtain significant differences for this factor. Despite the limitations of this study, this tendency must be considered in the context of gifted science education. Lower scores in Neuroticism in scientifically gifted students is an assumption as science education is often action-orientated and self-organized. Even if scores in Neuroticism are not particularly low, teachers should take care that the proposed method of work will not frustrate or discourage their students. Teachers should give students as much freedom as possible to challenge their self-management skills and self-confidence but should always be available as support (iPEGE, 2009; Sternberg, 2019).

We found no significant differences in Extraversion between scientifically gifted and nongifted students. In the context of scientific gifted education, results suggest that the use of scientific methods within science lessons is important. No differences in Extraversion were found for scientifically gifted students, which may provide obstacles for parts of inquiry-based learning like presentations or open group discussions (Bell et al., 2010). In Openness, scientifically gifted students showed significantly higher values than nongifted students. Individuals with high scores tend to be curious, imaginative, creative, are interested in new ideas, more tolerant when it comes to the unknown and engage in unconventional ways of thinking (Costa & McCrae, 2008; Pervin et al., 2005). Thus, conceptualizing a giftedness promotion in science based on action-oriented and problem-solving approaches with experiments and novel objects seems valuable (Van Tassel-Baska, 2013; Wegner & Fischer, 2013). Since teachers are asked to enable every student whether they are gifted or not to develop their individual potential (iPEGE, 2009), it might be beneficial to differentiate the level of inquiry instructions (Banchi & Bell, 2008) according to performance level. Our results showed that scientifically gifted students obtained significantly lower scorings for Agreeableness. A closer look at the interaction effect between scientific giftedness and grade level in Agreeableness showed no significant effect for grade level in the scientifically gifted cohort. Consequently, findings about Agreeableness in scientifically gifted students are not influenced by sex or grade level. The results recommend that further research should be done about the structure of social competencies in scientifically gifted students. As mentioned before, Agreeableness covers a continuum of possible characteristics in social behavior and low scores do not necessarily refer to a low social competency (Costa & McCrae, 2008). Riemann & Allgöwer (1993) found significant negative correlations between Agreeableness and Self-Assertation in students. As the structure of social competency in gifted STEM students has not yet been examined, effecting teaching methods are difficult to suggest. If social competency is weak, teachers need to include lessons for gifted students to build up their social skills and prepare them to work in science. All in all, it is still questionable as to how important social competency is for the expression of scientific giftedness and professional performance in STEM (Deming, 2017). We found that there are no significant differences between scientifically gifted and nongifted students for Conscientiousness, even if previous assumptions suggested otherwise. A study by Digman & Takemoto-Chock (1981) show that people with lower scores in Conscientiousness are actually aware of the questioned conventions but follow them less than their counterparts. Considering that Conscientiousness has a direct association with self-regulation and academic achievement (Eilam et al., 2009; Mammadov et al., 2018) and shows consistent relations to job performance (Barrick & Mount, 1991), teachers should offer more in-depth and technical experiments, beyond what the school usually provides, to positively influence scientifically gifted students' values.

Results showed no significant effects of gender on the five factors and that there was no gender-scientific giftedness interaction effect. This supports the assumption that scientific gifted education and practicing teachers should not particularly differentiate methods according to gender, which is in line with the results of TIMSS (Trends in International Mathematics and Science Study) (Wendt et al., 2016). There was a significant effect for grade level on Openness, where 4th and 5th graders showed significantly higher values compared to 7th graders. This suggests that within the group of scientifically gifted students, younger students are more open towards new experiences, potentially supporting the approach that their promotion should start in early childhood (NAGC, 2015; Schäfers & Wegner, 2020). Therefore, findings about scientific giftedness should be offered to elementary school or even kindergarten teachers.

Conclusion

Overall, scientifically gifted students' personality differed from those of nongifted students within the factor Openness and Agreeableness. Higher values in Openness support the assumption that scientifically gifted students should be promoted through self-organized, problem and action-orientated teaching (Bell et al., 2010; Van Tassel-Baska, 2013; Wegner & Fischer, 2013). Existing and future teacher trainings should take this into account and introduce their participants to this potentially successful way of working with scientifically gifted students, where teachers provide moderated support to free learning experiences. Agreeableness should be further studied, especially by examining social competency in gifted STEM students. Regarding a recommended teaching style, our results should be verified in additional studies using design-based research, to truly evaluate the actual effect on students' scientific academic achievement and their professional career (Shavelson et al., 2003).

Considering the limitations in this study, chosen methods could only determine trends in scientifically gifted students' unique characteristics and personality. Nevertheless, this is the first study on gifted students' personality using a combination of school nominations and assessments of an intelligence profile associated with scientific work to recruit a sample of domain-specific gifted students in STEM. Future studies must pay attention to methodological requirements in gifted research and use comparable samples with equal proportions in gender, age, and school type. Furthermore, our research approaches must be investigated with more in-depth instruments that are valid and reliable for the respective age group. Finally, to identify scientifically gifted students, direct measures of scientific giftedness must be further developed and implemented in school.

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Appendix. Specimen of the Used Questionnaire (Original Items of the NEO-FFI-30 (Körner et al., 2008) and Adapted Items)

Factor	Nr.	Original item (Körner et al., 2008)	Adapted item
Neuroticism	8	When I'm under a great deal of stress, sometimes I feel like I'm going to pieces.	
	12	I often feel tens and nervous.	
	…	…	
Extraversion	1	I like to have a lot of people around me.	
	5	I laugh easily.	
	…	…	
Openness	9	I am intrigued by the patterns I find in art and nature.	I am fascinated by the images I find in art and nature.
	14	Poetry has little or no effect on me. (R)	Poems have little or no effect on me. (R)
	21	Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement.	Sometimes when I am reading a book or looking at a work of art, I get goose bumps.
	22	I have little interest in speculating on the nature of the universe or the human condition. (R)	I have big interest in speculating on the nature of the universe or the human condition.
	27	I often enjoy playing with theories or abstract ideas.	I often enjoy playing with theories or unreal ideas.
	…	…	
Agreeableness	6	I often get into arguments with my family and co-workers.	I often get into arguments with my family and classmates.
	10	Some people think I'm selfish and egoistical. (R)	
	15	I tend to be cynical and skeptical of others' intentions. (R)	I tend to be skeptical of others' intentions. (R)
	…	…	
Conscientiousness	3	I keep my belongings neat and clean.	
	7	I'm pretty good about pacing myself so as to get things done on time.	
	…	…	