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Is there a "STEM Personality" in Germany? Linking Personality Traits with STEM Occupational Aspirations in German Secondary Education

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ABSTRACT

Across countries, young women are less likely to aspire to STEM occupations (science, technology, engineering, and mathematics) than young men. Since STEM occupations often entail higher wages, it remains important for researchers to explain gender differences in STEM. In this paper, we examine whether students' personality traits (Big Five) are associated with expressing preferences for STEM in German secondary education. To examine how girls and boys in secondary education match self-concepts of their personalities with beliefs about shared images of STEM occupations, we generate hypotheses based on Gottfredson's (1981) theory of Circumscription and Compromise. Associations between personality traits and STEM aspirations are examined by multinomial logistic regression for a cohort of ninth graders from the German National Educational Panel Study (NEPS). The results show that personality traits are differently related to subdomains within STEM occupations, particularly for young women. Increases in all traits lower pupils' likelihood of aspiring to scientific occupations and lower the likelihood of aspiring to technology aspirations. Despite the small and mostly insignificant effects, our results highlight the gendered processes of occupational formation at this age and underscore the relevance of providing more differentiated vocational guidance by gender and STEM domain.

KEYWORDS

Big-5 inventory; STEM; occupational aspirations; gender segregation; Germany

Is there a "STEM Personality" in Germany? Linking Personality Traits with STEM Occupational Aspirations in German Secondary Education

INTRODUCTION

Across countries, young women are less likely to aspire to enter STEM occupations (science, technology, engineering, and mathematics) than young men (Blaskó et al., 2018; Carnevale et al., 2020; Hägglund & Leuze, 2021). Since STEM occupations often entail higher wages (Kim et al., 2015; Michelmore & Sassler, 2016; Olitsky, 2014) and imbalances in them thus contribute to the gender wage gap, understanding what prevents young women from entering STEM fields continues to be an important research endeavour.

Previous research on gendered STEM occupational aspirations and choices has indicated that gender differences at the individual level – for example, related to maths and science performance or self-esteem, social influences through parents and peers, and contextual factors like the school environment – are important for understanding the gender gap in STEM. However, little is known about whether adolescents' personalities – in addition to these factors – are associated with the development of STEM preferences. This is surprising given that prominent theories on occupational preference formation, such as Gottfredson's theory of Circumscription and Compromise (Gottfredson, 1981; Gottfredson & Lapan, 1997), have stressed that the development of occupational aspirations depends on the alignment between an individual's self-image and their perception of occupations. Since personality is an essential basis for a person's self-image, the prevalence of specific personality traits should affect the development of STEM aspirations. In this paper, we therefore ask: To what extent are personality traits associated with expressing occupational STEM aspirations in secondary education?

To investigate personality traits, many researchers have applied the well-established Five Factor Model of Personality (Big Five) (McCrae & Costa, 2008), which differentiates between Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. So far, only a small number of studies based on the Netherlands (Coenen et al., 2021; Korpershoek et al., 2012) and Taiwan (Hong & Lin, 2011) has investigated whether these personality traits affect adolescents' STEM aspirations. These studies have generated inconclusive results. Gender differences in this regard have only been explicitly addressed by one study (Korpershoek et al., 2012), which identified that the association between Openness and field choice varies by gender. However, none of these studies has developed a theoretical framework that systematically links occupational preference formation with personality traits and addresses possible gender differences therein.

We add to this literature by investigating whether and how personality traits increase our understanding of why young adults develop preferences for STEM occupations. We focus on pupils' realistic STEM aspirations [1] in grade nine, which are an important precondition for studying and working in this area later on (Schoon, 2001; Weeden et al., 2020). To do so, we develop a theoretical framework based on Gottfredson's theory of Circumscription and Compromise (Gottfredson, 1981) and investigate the derived hypotheses separately for girls and boys to account for possible moderating gender effects. We analyse the case of Germany, which is characterised by strong occupational boundaries and strong institutional linkages between the education system and the labour market (Müller & Gangl, 2003). Therefore, in the German context, STEM occupational preferences developed in secondary schooling are particularly important for later STEM field choices in higher education and STEM occupational placement.

Empirically, we use a representative cross-sectional dataset of ninth graders from the German National Education Panel Study (NEPS) and estimate multinomial logistic regressions to determine the extent to which individual personality traits are related to occupational aspirations in STEM. Following the majority of previous literature on this topic, we define STEM occupations as academic occupations that require higher education credentials (see Stefani et al., 2021 for a discussion of different definitions)[2]. Moreover, we further disaggregate STEM occupations into those clearly dominated by men (i.e., engineering, technology) and those with a more gender-balanced distribution (i.e., maths, science) to account for possible heterogeneous gender effects (Mann & DiPrete, 2013).

Overall, this paper makes three contributions. First, we systematically focus on possible gender differences in the effect of personality traits on occupational STEM aspirations. Second, we develop a theoretical framework based on Gottfredson's theoretical approach to derive hypotheses on how girls and boys reconcile their self-concepts with stereotypical knowledge about occupations. Third, we do not analyse preferences for STEM occupations as a whole but instead differentiate between more gender-integrated mathematics and science (MaSc) occupations and more male-dominated engineering and technology (Tech) occupations to examine possible gender differences.

State of research

Previous research on the gender gap in STEM has identified important explanatory factors at the individual level, for example, gender differences in maths, science, or reading performance (Helbig & Leuze, 2012; Riegle-Crumb et al., 2012); self-esteem (Magnusson & Nermo, 2018); course-taking patterns in upper secondary school (Lörz & Schindler, 2011; Mann & DiPrete, 2013); or life and career plans (Morgan et al., 2013; Weeden et al., 2020). Gender differences have also been identified at the social level such as parents (Busch-Heizmann, 2015; Gabay-Egozi et al., 2015; Polavieja & Platt, 2014) or peers (Raabe et al., 2019; van der Vleuten et al., 2018) and at the contextual level like the school environment (Legewie & DiPrete, 2014). We add to this literature by focussing on personality as a possible further explanation for why adolescents develop STEM preferences.

The literature has proposed different definitions and concepts of personality, such as self-efficacy, motivation, interests, or traits (see Brody & Ehrlichman, 1998). Despite this heterogeneity of personality concepts, most authors agree that personality traits are important (Brody & Ehrlichman, 1998; Chamorro-Premuzic, 2015; Grönlund & Magnusson, 2018). Personality traits define a person's character and consistently affect his or her behaviour (Brody & Ehrlichman, 1998, p. 32). Most researchers investigating personality traits apply the well-established Five Factor Model of Personality (Big Five) (McCrae & Costa, 2008), which differentiates between five personality traits: Openness to Experience (inventive/curious vs. consistent/cautious), Conscientiousness (efficient/organised vs. extravagant/careless), Extraversion (outgoing/energetic vs. solitary/reserved), Agreeableness (friendly/compassionate vs. critical/rational), and Neuroticism (sensitive/nervous vs. resilient/confident) (Goldberg, 1993). The personality structure captured by the Big Five is relatively stable throughout the lifespan

(Brody & Ehrlichman, 1998; Chamorro-Premuzic, 2015) and across cultural contexts (McCrae & Costa, 2008), which sets it apart from self-efficacy, motivation, or interests. Regarding gender differences, women score higher on Agreeableness and Neuroticism then men, but research has found no consistent gender differences for the other traits (Costa et al., 2001; Grönlund & Magnusson, 2018; Vedel, 2016)[3].

When analysing the relationship between different personality traits and STEM preferences or choices, previous studies have mostly reported inconsistent results. The most robust finding for Western countries is a negative association between Extraversion and STEM for both genders. In secondary education, more extraverted students report lower STEM aspirations and are less likely to choose a science track (Coenen et al., 2021; Korpershoek et al., 2012). In tertiary education, students with STEM majors have the lowest Extraversion scores of all majors (Humburg, 2017; Kaufman et al., 2013; Rubinstein, 2005; Vedel, 2016). However, outside of the Western world, Hong & Lin (2011) have showed that, in Taiwan, Extraversion is positively associated with students' attitudes towards science in secondary education. This raises the question of whether the association between Extraversion and STEM is the same in different cultural contexts.

A neurotic personality also decreases the probability of aspiring to or choosing STEM. However, this influence is less clear in secondary education due to inconsistent results for middle school students (Coenen et al., 2021; Cupani & Pautassi, 2013; Korpershoek et al., 2012). Regarding maths performance in secondary education, one study also found moderating gender effects (Cupani & Pautassi, 2013): Neuroticism has a negative effect for boys but not for girls. In tertiary education, in contrast, research has consistently found the negative correlation for both genders (Clariana, 2013; Humburg, 2017; Rubinstein, 2005).

Openness seems to be more relevant in secondary education than at tertiary level. Moreover, its effect differs for girls and boys. In secondary education, more open ninth graders indicate a higher preference for STEM majors and occupations (Coenen et al., 2021). In tertiary education, in contrast, Openness is associated with social science subjects but not with STEM majors (Kaufman et al., 2013; Rubinstein, 2005; Vedel et al., 2015). Regarding gender differences, Korpershoek and colleagues (2012) identified a moderating effect of Openness[4] on STEM. Boys in a science-oriented subject track tend to have lower Openness scores than boys in a culture track, while it is the other way around for girls.

In the case of Agreeableness, results for secondary and tertiary education point in opposite directions for both genders. While studies on secondary education have found a negative association between Agreeableness and STEM preferences (Coenen et al., 2021; Korpershoek et al., 2012), studies on tertiary education have indicated that people with agreeable personalities more often choose (natural) science majors than other majors (Rubinstein, 2005; Vedel et al., 2015). Again, these findings may be more applicable in Western contexts, since Hong & Lin (2011) found that Agreeableness is positively associated with students' attitudes towards science in secondary education in Taiwan.

Finally, Conscientiousness is the trait less often associated with STEM aspirations or choices. Research conducted in Taiwan found that Conscientiousness is positively associated with students' attitudes towards science in secondary education for both genders (Hong & Lin, 2011). However, Coenen and colleagues (2021) only identified a positive correlation with STEM preferences for girls in the Netherlands. In tertiary education, Clariana (2013) only found a positive effect for women's preferences for technology at a Spanish university. Most other studies have not found any significant effect for this trait (Humburg, 2017; Korpershoek et al., 2012; Rubinstein, 2005).

In sum, previous research on the relationship between personality traits and students' STEM aspirations has mostly shown a negative association for Extraversion, Neuroticism, and Agreeableness – at least in Western contexts – while Openness and Conscientiousness seem to be positively correlated, at least for girls. However, none of these studies has developed a theoretical framework that systematically links occupational preference formation with personality traits and addresses possible gender differences therein.

The present study: Matching personality traits with stereotypes of STEM occupations

In the following, we apply Linda Gottfredson's (1981) Theory of Circumscription and Compromise to explain occupational aspirations. This approach draws on individual perceptions of the gender type and the status of different occupations to generate a "cognitive map of occupations" used by young people when developing occupational preferences. To derive hypotheses for the association between personality traits and STEM, we combine this approach with societal stereotypes about STEM occupations that might underlie the generation of these "cognitive maps" and attribute the positioning within the possible alternatives to personality differences.

Gottfredson's theory assumes that when developing occupational preferences, individuals seek to achieve a match between their individual self-concept and a set of occupations that are within their self-imposed decision space (Gottfredson, 1981). This matching is based on the step-by-step development of a person's ideas about suitable occupations (circumscription) and the adjustment process through which particular occupations are perceived as acceptable and accessible or not (compromise).

According to Gottfredson (1981; see also Gottfredson & Lapan, 1997), the development of occupational aspirations occurs in four stages, with each stage being associated with the elimination of a large number of "inappropriate" career alternatives. During the first stage (ages 3 to 5), children start to recognise occupations as adult roles and begin to identify real-life occupations as preferred options for adult life. In the second stage (ages 6 to 8), children perceive that men and women hold different occupations and begin to identify themselves with either male or female occupational roles, rejecting cross-gendered occupational choices. During the third stage (ages 9 to 13), children start to perceive differences in the societal valuation and status of particular occupations, thereby narrowing their occupational preferences to an acceptable status level. During the final phase, starting at age 14, young people begin to focus on aspects of "internal unique self" (Gottfredson & Lapan, 1997, p. 423) – in other words, their motivation, values, and abilities and how these correspond to certain occupations. We assume that, at this stage, personality traits come into play and influence the selection of particular occupations within the zone of acceptable alternatives.

How does personality affect who develops MaSc or Tech preferences? According to Gottfredson, adolescents match the existing occupational images with "one's sense of self" (Gottfredson, 1981, p. 547). This idea is further developed in the concept of self-to-prototype matching (Hannover & Kessels, 2004). It assumes that individuals use a cognitive strategy when choosing a particular option – in our case, a particular occupation – by imagining a prototypical person in each of the possible options. Subsequently, they compare these prototypical persons with the image they have of themselves. Finally, they select the option with the best match between prototypical and self-image (Hannover & Kessels, 2004; Niedenthal et al., 1985; Setterlund & Niedenthal, 1993). We assumed that young adults think about stereotypical images of a scientist or an engineer and consider whether these stereotypes correspond to the self-perception of their own personality (see also Gottfredson, 1981). Consequently, we assumed that adolescents aspire to a STEM job if they perceive a match between the stereotypical image and their individual personality. In the following, we describe the occupational stereotypes of the two STEM domains – natural scientists and engineers – on the basis of empirical literature and discuss possible links with the various personality traits (McCrae & Costa, 2008; Simari et al., 2021).

Stereotypes of "MaSc people" – Natural scientists

Probably the most studied occupational stereotype is that of the (natural) scientist. According to empirical studies, this stereotype mostly depicts scientists as having low levels of Extraversion. High levels of Extraversion are associated with a "(…) warm, outgoing and cheerful (…)" personality, while low levels of Extraversion depict a "(…) reserved, solitary and somber (…)" personality (McCrae & Costa, 2008, p. 274). Low levels of extraversion are most often depicted in stereotypical visual images of the natural scientist, who is described as "always reading a book", only focussing on their research, and having unkempt hair and a beard (Mead & Métraux, 1957, p. 387). These visual stereotypes are also reflected in the pictorial representations within the "Draw a Scientist Test" (Chambers, 1983; Miller et al., 2018) and are reproduced in the colloquial term "boffin". The tension between the "truly wonderful" (Mead & Métraux, 1957, p. 387) but socially deprived scientist is also reflected in the media in terms ranging from "savior of the society" to "evil alchemist" (Haynes, 2003, p. 244). Low levels of Extraversion have also been highlighted by Carli and colleagues (2016), who noted that scientists are perceived as performance- and action-oriented rather than communicative. Accordingly, natural scientists are perceived to have a less pronounced social inclination, since expressions of social skills (e.g., charm or friendliness) are lower for natural scientists than social scientists (Roe, 1953) or business persons (Bendig & Hountras, 1958). Consequently, in visual terms, scientists are not particularly attractive to young people (Archer et al., 2010).

Moreover, scientists are often stereotypically associated with high levels of Conscientiousness, "(…) which characterizes people who are hardworking, purposeful and disciplined rather than laid-back, unambitious and weak-willed (…)" (McCrae & Costa, 2008, p. 274). This is reflected in descriptions provided by Kelly and Weinreich-Haste (1979, pp. 288–290) – irrespective of gender, these descriptions characterize scientific subjects as factual and highly complex; they link them to "non-normality" and "brilliance". Head and Ramsden (1990, p. 120) found that young women who chose a science major are "realistic decision-makers who focus on facts of immediate experience (...), seek an ordered environment and are organized and dependable (...), prefer to solve problems by relying on past experience and dislike ambiguity in a situation". Similarly, Archer et al. (2010) found in interviews that children link scientific activities to perseverance and concentration rather than to special aptitude.

In summary, (natural) scientist are, on the one hand, stereotypically assumed to have low levels of Extraversion (H1a), as indicated by social deprivation. On the other hand, they point towards high levels of Conscientiousness (H1b), indicated by high goal orientation and an understanding of complexity.

Stereotypes of "Tech people" – Engineers
Stereotypes of "tech people", i.e., engineers, are also mostly associated with high levels of Conscientiousness and low levels of Extraversion, although more emphasis is placed on the former. In addition, the stereotypical image of an engineer suggests high levels of Openness.

Most often, engineers are stereotypically ascribed high levels of Conscientiousness; they are viewed as "(…) hardworking, purposeful and disciplined (…)" (McCrae & Costa, 2008, p. 274). This stereotype of engineers is in line with the dispassionate focus on technical and scientific processes (National Academy of Engineering, 2008). Much of the scholarly knowledge on the conventional image of engineers is based on research related to the "Draw an Engineer Test" provided by Cunningham and colleagues (2005). This research suggests that for pupils of all ages, an engineer is first and foremost a person who fixes, makes, constructs, or builds things (Fralick et al., 2009; Knight & Cunningham, 2004; Lachapelle et al., 2012). The stereotype of an engineer is that of a "skilled craftsmen" (Karatas et al., 2011, p. 133), that is, a labourer or mechanic who works with objects like cars, tools, or computers (Fralick et al., 2009; Knight & Cunningham, 2004). Especially in elementary school, students' images of engineers seem to consist of specific attributes rather than actions related to the profession (Cunningham et al., 2005; Lachapelle et al., 2012). The stereotype of an engineer (especially for secondary school students) is a "(…) 'doer' or 'worker bee' rather than [a person] focusing on mental aspects" (Fralick et al., 2009, p. 65). They prefer a direct, systematic approach that is things-orientated and allows little tolerance for ambiguity (Beall & Bordin, 1964). Apart from that, engineers describe themselves as ambitious, accurate, and clear-thinking (Szewczyk-Zakrzewska & Avsec, 2016).

Sometimes, stereotypes of engineers are also associated with low levels of Extraversion, albeit to a lesser extent than those of natural scientists and with a stronger emphasis on a dispassionate and realistic personality. Self-descriptions of engineers indicate that they tend to exhibit casual relationships that are characterised by both a lack of self-understanding (Harrison et al., 1955) and low awareness of the needs of others (Beall & Bordin, 1964). Clear hierarchical structures seem to suit them more when interacting with others than passions and affective actions (Beall & Bordin, 1964). This is in line with the common impression that engineers make stronger leaders than scientists, who are perceived to be less suited to executive roles (National Academy of Engineering, 2008).

Finally, some stereotypes of engineers relate to high levels of Openness, which refers to "(…) imaginative, curious and exploratory tendencies (…)" in personality as opposed to "(…) rigid, practical and traditional tendencies (…)" (McCrae & Costa, 2008, p. 274). Interestingly, this personality trait is more strongly related to tech stereotypes developed by older pupils or by engineers themselves. For younger children, tasks like designing or inventing are seldomly related to the image of an engineer, while engineers themselves emphasise the importance of these skills for their job (Lachapelle et al., 2012). Knight and Cunningham (2004) have also shown that this aspect of the engineering profession becomes more prevalent with age, since students from grade nine onwards relate engineering more often to designing than younger students.

In summary, stereotypes of tech persons are associated with high levels of Conscientiousness (H2a) reflected in planned, organised work and a confident demeanour. Additionally, having a dispassionate, grounded, and realistic personality is associated with low levels of Extraversion (H2b). Finally, the stereotype is linked to a relatively high expression of Openness, as an engineer is perceived to design or invent new things (H2c).

Gender differences in the effect of personality traits on STEM aspirations
Regarding gender differences in personality traits, women score higher on Agreeableness and Neuroticism than men, while there are no consistent gender differences for the other traits (Costa et al., 2001; Grönlund & Magnusson, 2018; Vedel, 2016). Since neither Agreeableness nor Neuroticism are systematically related to the stereotypical images of natural scientists or engineers, we did not expect personality traits to mediate the effect of gender on STEM aspirations – in other words, they should not contribute to the gender gap in STEM.

However, both the images of natural scientists and of engineers are stereotypically male. Much of the existing research on images of natural scientists centres on this being male. For example, an early study by Mead and Métraux (1957, p. 386) indicated that the scientist is "(...) a man who wears a white coat (...)". Miller and colleagues (2015) showed that, across countries, science is associated more strongly with men than with women, yet they also found cross-national variations. Finally, Carli and colleagues (2016) found that there was greater similarity between stereotypes about men and stereotypes about successful scientists than was the case for women. Likewise, engineering is seen as a typical male profession, both in conventional stereotypes and self-descriptions. When pupils are asked to draw an engineer, they predominantly draw men (Karatas et al., 2011; Knight & Cunningham, 2004). Moreover, engineering books or engineers' autobiographies accentuate masculinity (Beall & Bordin, 1964).

So, why should some young women nevertheless aspire to MaSc or Tech occupations? We assume that girls only develop preferences for these gender-atypical occupations if they score rather high on the relevant personality traits. Therefore, the effect of these personality traits should be stronger for young women than for young men when explaining their occupational aspirations to STEM.

METHODS

Data and sample selection

For our study, we used data from of the German National Educational Panel Study (NEPS) (Blossfeld et al., 2019; NEPS Network, 2021)[5]. This longitudinal study aims "(…) to collect data on the acquisition of education, to assess the consequences of education for life courses, and to describe central educational processes and trajectories across the entire life span" (Skopek et al., 2013, p. 14). Our study used data from starting cohort four (NEPS SC4), which surveyed the educational trajectories of pupils from ninth grade onwards. The sample was based on a population of ninth graders in Germany for the school year 2010/2011, which was sampled through a multistage approach (Skopek et al., 2013).

Generally, the German secondary schooling system is defined by early between-school tracking, whereby pupils are sorted into different school tracks at age ten

(Strello et al., 2021). Pupils attending the low *Hauptschule* track or the intermediary *Realschule* track mostly attain intermediary school-leaving certificates that allow them to enter the German vocational education and training system. In contrast, only pupils attending the highest track, a *Gymnasium*, or comprehensive schools with a Gymnasium track can be awarded higher education entry certificates that allow them to attend university. Since we define STEM occupations as academic occupations requiring higher education credentials (Stefani et al., 2021), we only included pupils attending the Gymnasium or comprehensive schools[6] in our analytical sample. We assumed that, due to strict tracking of secondary schooling in Germany (Allmendinger, 1989), only this subgroup of pupils would be likely to develop realistic STEM occupational aspirations, while this should not be the case on the lower school tracks. To check the robustness of this assumption, we additionally estimated our models for the full sample including pupils on all school tracks and for a reduced Gymnasium track sample.

We analysed the first two waves of NEPS SC4 (Blossfeld et al., 2019), which contained information on students' personality and realistic occupational aspirations. Personality was measured in wave one at the beginning of grade nine, while occupational aspirations were measured in wave two during the second half of grade nine. Since there was little panel attrition between those two waves (only 7.4% of pupils left), we treated our sample as a cross-section. The original representative sample followed 14,540 ninth graders across their educational career. Due to the restriction of our sample to students attending a Gymnasium or comprehensive school, our sample contained N=6,194 pupils, with 3,314 girls and 2,880 boys before imputation. For the descriptive and the multiple analyses, we weighted the data with calibrated and standardised weights for wave-specific nonresponse and the sampling stratification (Steinhauer & Zinn, 2016).

Measures

To measure our dependent variable, namely realistic occupational aspirations, we used pupils' open answer to the question "Consider everything you know right now. What will probably be your occupation in the future?" in ninth grade. The open answers were re-coded by the NEPS team into the five-digit version of the German Classification of Occupations 2010 (KldB 2010 5-digit) (Paulus & Matthes, 2013). Based on these numerical occupational codes, we generated a new variable, which groups pupils' realistic occupational aspirations into four categories: aspirations to enter (1) science and mathematics occupations (MaSc), (2) engineering and technology occupations (Tech), (3) Non-STEM occupations, and (4) a category for pupils unable to indicate a realistic occupational aspiration ("Do not know"). To categorise the MaSc and Tech occupations, we applied the definition of expert STEM occupations as issued by the German Federal Employment Agency (2019), which only includes STEM occupations that require higher education credentials. The division into subcategories resembled the classification of Mann and DiPrete (2013)[7]. A list of occupations included in these two categories is presented in Online Supplementary Materials 1 and 2. Students who indicated a certain career aspiration but did not express either a Tech aspiration or a MaSc aspiration were assigned to the Non-STEM category, while those without a certain aspiration were categorised as "Do not know"[8]. To check the robustness of our results, we additionally examined whether pupils aspired to STEM aspirations (1; merging Tech and MaSc) or not (0; merging "Non-STEM" and "Do not know").

Our main independent variables were personality measures based on a micro-questionnaire (BFI-10) of the original NEO-PI-R Big Five scale implemented by

Rammstedt and John (2007). In this short instrument, each personality trait was measured by two items with the exception of Agreeableness, where three items were used due to the higher validity for this factor (Rammstedt & John, 2007)[9]. All questions were measured with a 5-point Likert scale. We computed the mean of the items for each personality trait, ranging from 1 (low values) to 5 (high values).

To check whether these personality traits affected pupils' realistic STEM aspirations in addition to other explanations found in the literature, we controlled for several factors at the individual and social level. At the individual level, we considered age variations (Eccles, 1994) by respondents' birth year; migration status (Relikowski et al., 2012), measured by whether respondents or their parents were not born in Germany; domain-specific self-concepts (Sikora & Pokropek, 2012) in mathematics and German, measured by multiple items scaled from 1 to 4 (Wohlkinger et al., 2016); competences (Helbig & Leuze, 2012) in reading, mathematics, science, and ICT (as weighted maximum likelihood point estimates (WLEs), see Pohl and Carstensen (2012) for estimation details); and whether students expected to obtain a higher-education entry certificate (Abitur). At the parental level, we considered the parental socio-economic status, measured by the International Socio-Economic Index of Occupational Status (ISEI)[10], two dummy variables for whether the father or the mother worked in a STEM occupation, and parental educational aspirations, measured by one item on the importance given to good school grades (5-point Likert scale).

Data analyses

Descriptive statistics for all variables are presented in Table 1; separate statistics for girls and boys are found in Appendix A. An overview of the data cleaning as well as the specific operationalisations can be found in Online Supplementary Materials 3 and 4. Of all students in the full sample, only 2% aspired to a career in the MaSc field and 5% aspired to a career in Tech. While more than half of all students aspired to a Non-STEM career, 42% were still uncertain about their future career at this point. However, large gender differences prevailed within the STEM subfields: While among boys, 3% (*n*=83) had MaSc aspirations and 7% (*n*=189) revealed state Tech aspirations, the corresponding proportions among girls amounted to 1% (*n*=43) for MaSc and 4% (*n*=130) for Tech. Thus, in grade nine, very few pupils from both genders actually expected to work in STEM occupations later on, yet the gender gap in STEM was already observable.

There were various missing values across the different variables. Therefore, we imputed missing values for the personality variables, socio-economic status, and the aspired secondary education certificate by chained imputation with STATA 16 (30 imputations). We dropped observations with missing ratios below 1% on competences, self-concepts, and demographics (listwise deletion), leading to an analytical sample of 5,902 students (3,170 girls and 2,732 boys). To test our hypotheses, we used multinomial logistic regressions of the weighted and imputed covariates on our four aspiration categories (reference category: Non-STEM). To better interpret the results, we graphically present average marginal effects (generated by mimrgns-package by Klein (2014)) of all models (by outcome) when the independent variable is increased by one unit. We present unit changes, since the standard deviations of personality traits are between 0.64 and 0.97 (see Appendix A). Thus, a unit increase closely represents the mean variation of the sample, but is more easily interpreted than the standard deviation. All other values are held constant at their observed values. Results are wrapped in coefficient plots in the following figures. Detailed marginal effect tables by outcome are found in Appendix B and Appendix C.

Table 1
Descriptive statistics [weighted] (N=6,194)

Total (both genders)	Mean / Share	*SD*	Min	Max	*N* (before imputation
Girls	0.54				3,314
Occupational aspirations (shares)					
Math/Science (MaSc)	0.02				126
Technology/Engineering (Tech)	0.05				319
Non-STEM	0.51				3,173
Do not know	0.42				2,576
Big Five traits					
Extraversion	3.46	0.90	1.00	5.00	6,088
Agreeableness	3.43	0.66	1.00	5.00	6,071
Conscientiousness	3.07	0.88	1.00	5.00	6,110
Neuroticism	2.75	0.87	1.00	5.00	6,087
Openness	3.53	0.97	1.00	5.00	6,097
Parental controls					
Importance of grades for parents	4.27	0.85	1.00	6.00	5,996
STEM occupation father	0.08				6,194
STEM occupation mother	0.02				6,194
Socio-economic status [ISEI-08]	55.26	23.54	0.00	88.96	5,371
Migration background dummy	0.26				6,191
Individual-level controls					
Year of birth	1995	0.64	1993	1998	6,194
Reading competences	0.52	1.18	-3.39	3.30	6,168
Math competences	0.62	1.27	-3.56	4.62	6,191
Science competences	0.43	0.98	-2.52	5.29	6,174
ICT competences	0.42	0.90	-3.30	4.05	6,177
Self-concept German	2.99	0.62	1.00	4.00	6,068
Self-concept math	2.55	0.93	1.00	4.00	6,045
Realistic aspiration for Abitur	0.73				5,920
Observations	6,194				

RESULTS: GENDER DIFFERENCES IN THE ASSOCIATION BETWEEN PERSONALITY TRAITS AND STEM

How do personality traits contribute to our understanding of STEM preferences? Figure 1 presents average values for the Big Five for MaSc aspirations, Tech aspirations, and Non-STEM aspirations. Pupils with Tech aspirations scored highest on Openness and Extraversion. In contrast, pupils with MaSc aspirations had the lowest values on Extraversion while they were closer to the mean of the Non-STEM group in all other traits. Both Tech and MaSc aspirations were associated with the lowest values in Neuroticism. A chi-squared test showed significant differences between the groups for all five personality traits (for Agreeableness and Conscientiousness just at the 10% level). Thus, these descriptive results point towards different personalities for "MaSc people" and "Tech people".

Figure 1

Personality traits and occupational aspirations, mean values

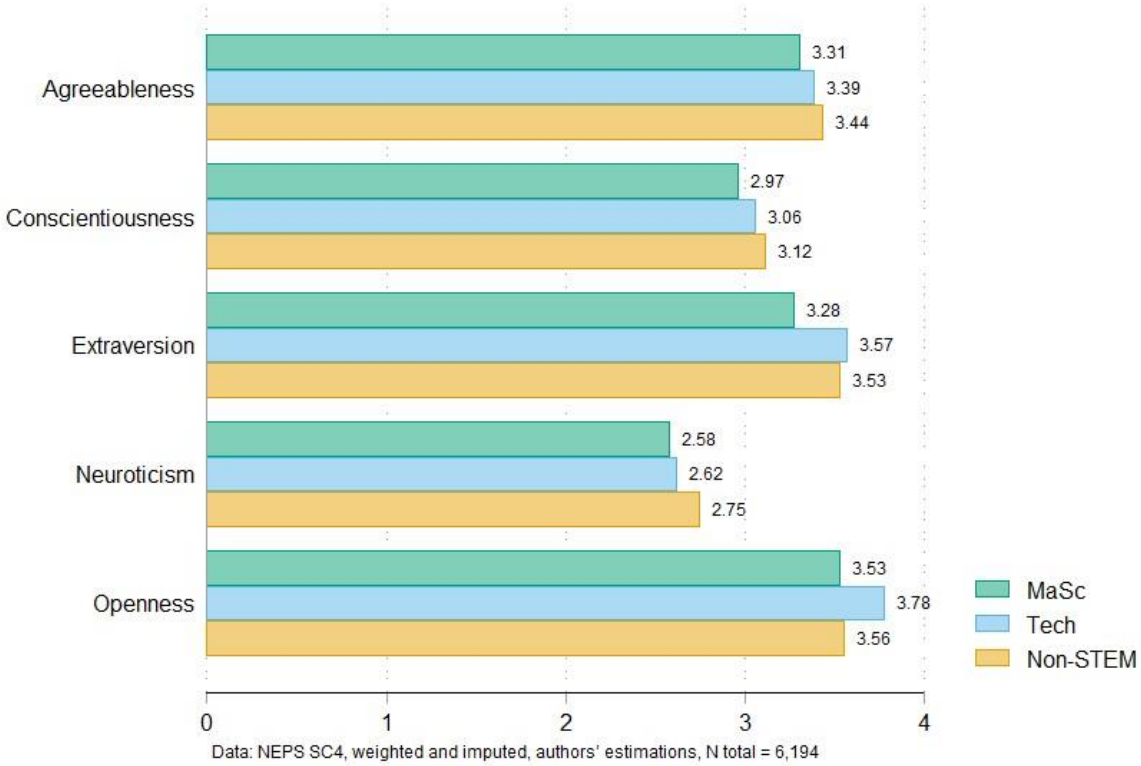
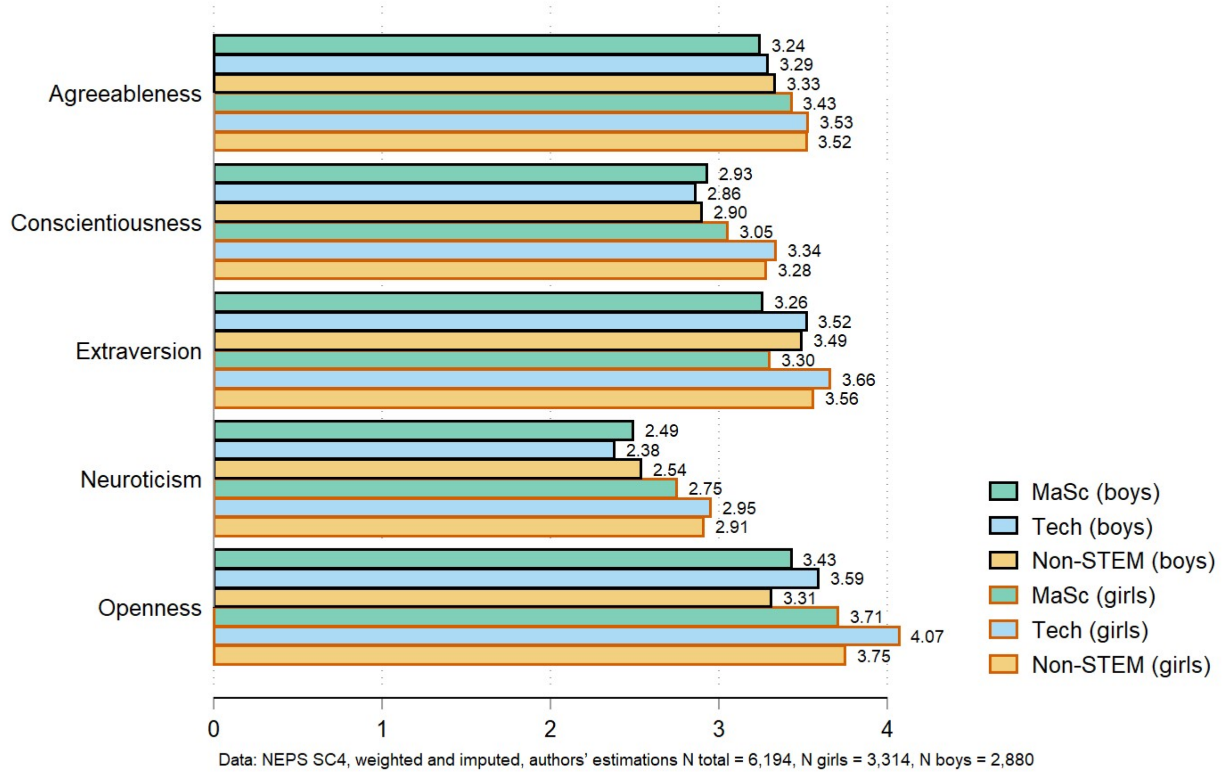


Figure 2
Personality traits and occupational aspirations by gender, mean values



Regarding gender differences, girls scored higher than boys on all Big Five traits and for all types of occupational aspirations (see Figure 2 and Appendix A). Girls with Tech aspirations exhibited higher values on all traits, while girls aspiring to MaSc occupations had lower values on all personality traits than those aspiring to Non-STEM occupations (significant only for Extraversion, Conscientiousness, and Openness). For boys, in contrast, no clear pattern emerged. Boys with Tech preferences had the highest values on Extraversion and Openness, while boys with MaSc aspirations had the highest values on Conscientiousness. Boys with Non-STEM preferences scored highest on Agreeableness and Neuroticism (significant ingroup difference for Extraversion, Agreeableness, and Neuroticism). The gender comparison indicated that the higher personality values of Tech aspirations were mostly driven by girls. Moreover, the personalities of those aspiring to MaSc and those aspiring to Tech were more distinct among young women than among young men, which was most obvious for the traits Conscientiousness and Openness.

How did these personality differences relate to aspirational differences once controlling for relevant covariates? Figure 3 and Figure 4 present the results of the multinomial regression analyses for girls' and boys' occupational aspirations. The plots summarise the results of average marginal effects for each occupational field when we increased the personality traits by one unit and considered all covariates.

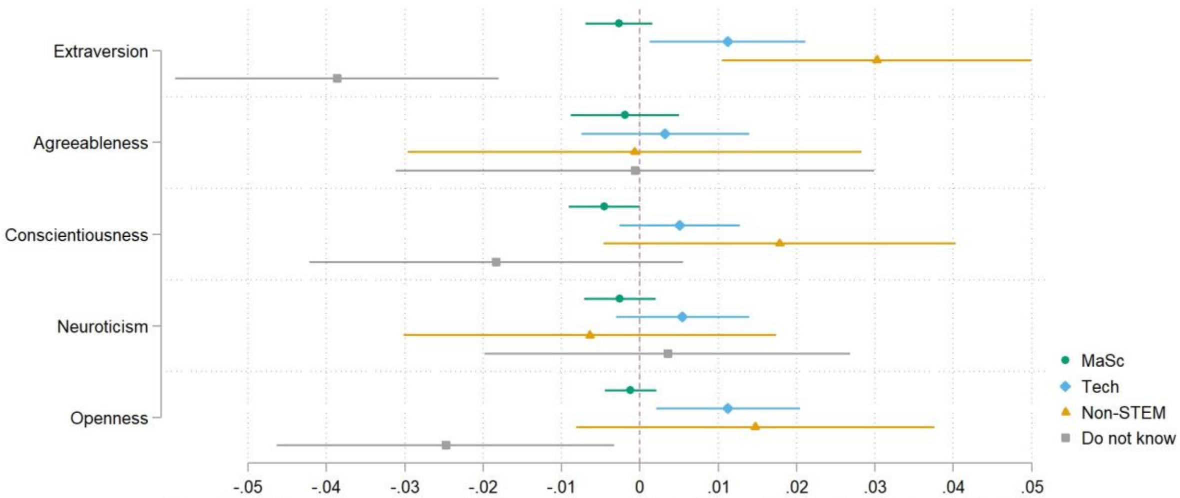
Looking at the results for girls in Figure 3, almost none of the personality traits were significantly related to aspirations to enter MaSc occupations. Interestingly, however, the effect of all trait dimensions was negative, indicating that increases in all personality traits decrease the probability of girls' MaSc aspirations. The largest and only significant effect was found for Conscientiousness: An increase of one scale point decreased girls' probability of aspiring to MaSc occupation by about 0.5

percentage points. This contradicts H1b. Even though the effect seems rather small, it must be evaluated in light of the fact that only 1% of all girls aspire to MaSc occupations on average, which points to its relevance. However, this effect emerged only when individual-level control variables were considered (see Online Supplementary Material 5).

In contrast, all effects for Tech aspirations were positive, although only two had effects reaching significance. Among girls, higher levels of Openness increased the likelihood of holding Tech aspirations, which supports H2c. A one-unit increase in Openness increased the probability of Tech aspirations by about 1 percentage point. Given that only about 4% of girls on average aspired to enter Tech occupations, this effect size seemed rather substantial. In a similar vein, girls with higher levels of Extraversion were more inclined to prefer Tech, which speaks against H2b. Again, the effect is about 1 percentage point for a 1-unit increase of Extraversion, indicating its relevance for Tech aspirations. Yet it only emerged after controlling for individual-level factors (see Online Supplementary Material 5).

Figure 3

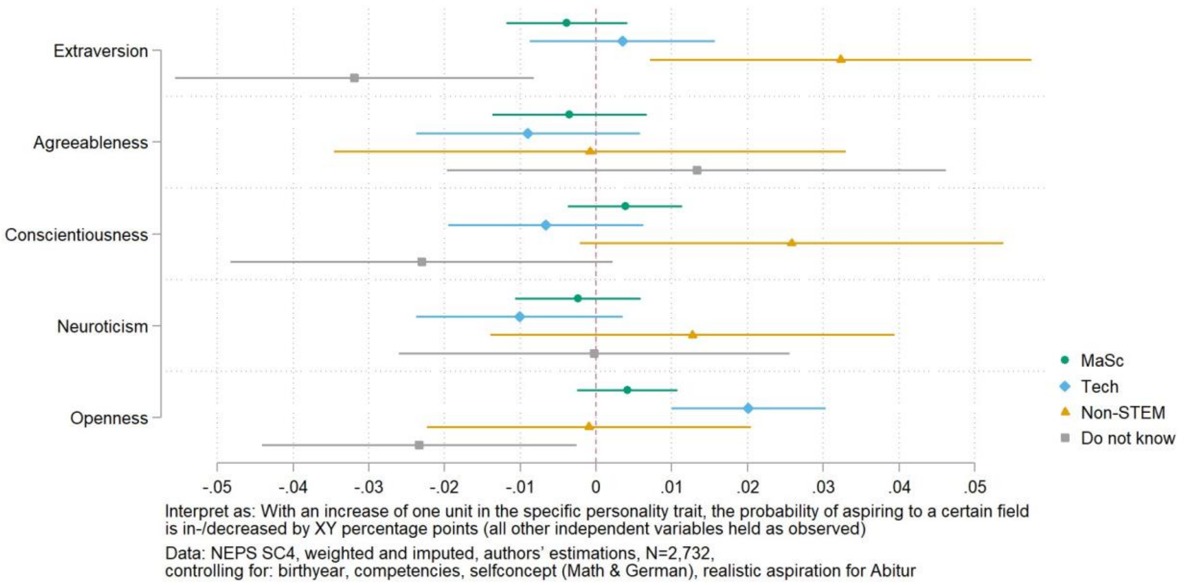
Personality traits and girls' occupational aspirations, average marginal effects with 95% confidence intervals



Interpret as: With an increase of one unit in the specific personality trait, the probability of aspiring to a certain field is in-/decreased by XY percentage points (all other independent variables held as observed)

Data: NEPS SC4, weighted and imputed, authors' estimations, N=3,170, controlling for: birthyear, competencies, selfconcept (Math & German), realistic aspiration for Abitur

Figure 4
Personality traits and boys' occupational aspirations, average marginal effects with 95% confidence intervals



A slightly different picture emerged when looking at the association between boys' personality traits and their occupational aspirations (see Figure 4). We found that no personality trait was significantly associated with boys' MaSc aspirations. Even though we found a slightly positive effect for Conscientiousness and a slightly negative effect for Extraversion, as assumed in H1a and H1b, these effects were very small and not significant at $p < .05$. One possible explanation might be that only about 3% of all boys in our sample aspired to MaSc occupations, which might be too low to find significant effects.

Regarding boys' Tech aspirations, a significant and positive association was only evident for Openness, as assumed in H2c. A one-unit increase in Openness increased the probability of aspiring to a Tech occupation by about 2 percentage points. Even though this effect seems rather small, it must be considered against the background that only 7% of boys aspired to a Tech occupation. Thus, a more open personality did indeed contribute substantially to boys' preferences for Tech occupations. In contrast, for Agreeableness, Conscientiousness, and Neuroticism, we found slightly negative yet not significant effects, while the effect of Extraversion was slightly positive, though – yet again – not significant. These results were largely robust when considering control variables on the parental and individual level (see Online Supplementary Material 6). Only the negative effect of Neuroticism turned insignificant once competencies and self-concepts were considered.

Overall, these results indicate that only selected personality traits seemed to matter for girls' and boys' STEM aspirations. Interestingly, however, personality appeared to be more important for understanding which ninth graders would develop Non-STEM aspirations or did not know yet which occupation to prefer. More extraverted pupils were more likely to aspire to Non-STEM occupations and were less likely to state no clear occupational preference. The same pattern held true for

Conscientiousness, albeit not significantly. Finally, more open ninth graders were also less likely to be found in the "Do not know" category.

We applied various robustness checks to test the validity of our results. We first checked the robustness of our sampling strategy, namely by including only pupils attending the Gymnasium and comprehensive schools. We narrowed the sample to pupils of the classical Gymnasium (*N*=4,497), which yielded similar results to the full sample (see Online Supplementary Material 7). Further, we expanded our sample by including pupils on all school tracks (except for special needs schools). Results indicated that the associations between personality and occupational aspirations became weaker, with only the positive effect of Openness on Tech aspirations remaining significant. For girls, the effect directions of personality traits remain the same, while for boys, the effect of Extraversion turned from positive to negative (see Online Supplementary Materials 8 and 9).

Second, we checked the robustness of the coding of our dependent variable and gender differences therein. We estimated the effect of personality traits for the full sample (see Online Supplementary Material 10) and on the overall STEM category (see Online Supplementary Material 11). For both, we could only reproduce the effect for Openness, which is not surprising given that all other effects differed between the different STEM domains and between girls and boys. In addition, we examined the extent to which aggregation of the "Do not know" group obscured within-variation. An examination with separate specifications for item nonresponse produced only slightly different results but did not change the direction of the effects.

Finally, we compared various weighting and post-stratification procedures. The final choice for the complex survey design weight was due to the school-based stratification, which was not reflected in more simple weightings. Any variations confirm the results of our models.

DISCUSSION

The gender gap in STEM is a worldwide phenomenon. Therefore, it is important for researchers to understand what deters young women from entering STEM occupations. We contributed to this large body of research by asking whether pupils' personality traits in grade nine are systematically associated with their STEM aspirations. We focussed on realistic occupational aspirations since they are an important first step for adolescents in their occupational choice process (Gottfredson & Lapan, 1997). Moreover, gendered occupational plans or preferences have been shown to result in gendered career outcomes (Morgan et al., 2013; Weeden et al., 2020). So far, very few studies have investigated the role of personality traits for STEM occupational aspirations in secondary school; research has only been conducted in the Netherlands (Coenen et al., 2021; Korpershoek et al., 2012) and Taiwan (Hong & Lin, 2011).

Empirically, we used a cross-sectional dataset of ninth grade pupils from the German National Education Panel Study (NEPS), starting cohort 4, to examine the extent to which their personality is related to their career choice process. Overall, we can conclude that only some personality traits are associated with preferences for STEM occupations. Based on bivariate associations, we find similarities and differences with the previous literature. In line with previous studies, Neuroticism seems to be negatively associated with STEM occupational aspirations (Coenen et al., 2021; Cupani & Pautassi, 2013; Korpershoek et al., 2012). However, our differentiation between more male-dominated Tech occupations and more integrated MaSc occupations indicated that Openness is only positively associated with STEM in the case of Tech (Coenen et al., 2021). In contrast, lower values of Extraversion are only associated with MaSc aspirations (Coenen et al., 2021; Korpershoek et al., 2012), while the reverse is true for Tech aspirations. Thus, our descriptive results already point towards different personalities for "science people" and "tech people". This indicates that our strategy of further disaggregating STEM occupations was justified.

The most robust finding of the multinomial regression analyses for both genders is that higher levels of Openness increase pupils' Tech aspirations: The tech stereotype is characterised by a relatively high expression of Openness, since engineers are perceived to design or invent new things. This finding also supports previous research, which states that more open ninth graders indicate a higher preference for STEM (Coenen et al., 2021). However, we cannot conclude that the effect is stronger for girls than for boys but rather that it is similar for both genders. Thus, Openness does not help girls to develop more gender-atypical occupational preferences. Rather, it is more strongly related to the content of engineering and technology occupations for girls and boys alike. These findings contrast with findings for the Netherlands, where boys in a science-oriented subject track tended to have lower scores in Openness than boys in a culture track, while it was the other way around for girls (Korpershoek et al., 2012).

Interestingly, however, higher levels of Extraversion seem to support girls developing Tech preferences. This contradicts the stereotypical image of an engineer as having a dispassionate, grounded, and realistic personality, and thus, low levels of Extraversion. Moreover, this finding does not support previous research, according to which more extraverted students report lower STEM preferences (Coenen et al., 2021; Korpershoek et al., 2012). It is therefore possible that girls need higher levels of Extraversion when developing gender-atypical occupational preferences given that they are likely to be a visible gender minority in this domain. In this regard, it is also worth noting that the personalities of young women with STEM aspirations differ more from those of the full sample; this finding is similar to those reported by Coenen et al. (2021). In theoretical terms, we assumed members of a minority group needed a more pronounced personality when entering certain occupational fields in which their minority is less represented. In this sense, we find a higher likelihood of more extraverted and open-minded women, and especially so for the more gender-atypical area of Tech aspirations. This demonstrates both the theoretical and the practical relevance of a disaggregated view of the STEM fields.

No other personality traits are systematically related to girls' and boys' Tech aspirations. This also contradicts our assumption that stereotypes of "tech persons" would be associated with high levels of Conscientiousness – in other words, we expected them to be linked to planned, organised work and a confident demeanour. However, the effect directions are different for both genders. While higher levels of Agreeableness, Conscientiousness, and Neuroticism tend to increase girls' Tech preferences, it is the other way around for boys.

We found hardly any significant results are a for MaSc aspirations, which might be the result of the very small group sizes in the MaSc category for both genders. Nonetheless, these findings speak against both of our hypotheses. We first assumed that the stereotypes of a scientist would be associated with lower levels of

Extraversion, as indicated by a socially deprived personality. Even though the direction of Extraversion is negative for both genders, which is consistent with previous research (Coenen et al., 2021; Korpershoek et al., 2012), it does not reach significance, and therefore, only lends tentative support to this assumption. We further assumed that high levels of Conscientiousness, implied by high goal orientation and an understanding of complexity, should increase MaSc aspirations. For boys, the effect of Conscientiousness is indeed positive, albeit it is again not significant. For girls, in contrast, it is negative, indicating that less conscientious girls prefer MaSc occupations. It is possible that other stereotypes than the ones discussed here are relevant in this regard. Since girls are generally more conscientious and more inclined to prefer Non-STEM occupations, less conscientious girls are also less stereotypical, which might explain their preference for atypical MaSc occupations.

Overall, our results indicate Openness and Extraversion to be beneficial traits for Tech aspirations, with the latter being significant only for girls. Conscientiousness is the only trait negatively affecting MaSc aspirations – again, only for girls. These findings are only partly in line with previous research, which consistently found negative associations for Extraversion and, to a lesser extent, for Neuroticism and Agreeableness, but positive effects for Openness and Conscientiousness. Therefore, we argue for researchers to use more differentiated measures of STEM sub-domains, such as the ones we used in this paper, and for considerations of their relation to personality traits. This is supported by Capretz's (2003, p. 214) statement "it takes variety to conquer variety" for personality variation in the information technology sector. Therefore, it seems useful to differentiate between different STEM occupations when investigating how young people develop their career preferences in future studies.

Regarding the theoretical derivation of our hypotheses, the Theory of Circumscription and Compromise (Gottfredson, 1981) provided a good starting point for understanding how pupils reconcile their unique selves with perceived stereotypes about "science people" and "tech people". However, our empirical data only supports one derived hypothesis, which calls into question the literature on occupational stereotypes in STEM domains. Although these results differentiate stereotypes at the micro level, we found very limited variation between MaSc and Tech when they are combined within the personality traits framework. On the one hand, these empirically derived stereotypes might already be outdated. This might lead to bias in our assumptions, since they are based mostly on older studies. However, it is also possible that society in general and students in particular only have a very vague idea of these stereotypes (Fralick et al., 2009; Karatas et al., 2011; National Academy of Engineering, 2008). In line with the theoretical assumptions of self-to-prototype matching, it is also conceivable that insufficiently developed personalities at the ages we considered may hinder matching. Therefore, the matching processes might be based on incorrect or imprecise images of the respective STEM occupations (Rommes et al., 2007). Moreover, gender stereotypes have likely changed over time, since the proportion of women in STEM today is much higher than it was when many studies on stereotypes were published (Miller et al., 2015). Rather than disregarding the explanatory value of Gottfredson's approach in general, we suggest conducting more up-to-date studies on the societal stereotypes of "science people" and "tech people".

Limitations
Of course, our study faces some limitations. The first relates to the low number of cases in our relevant STEM categories of occupational aspirations. Even though our full sample consists of 5,902 cases, the phenomenon of interest only applies to a small proportion of the students, namely 2% (MaSc) and 5% (Tech). In particular, the low number of young people in our sample who are interested in MaSc occupations might explain the lack of significant results.

The second relates to the cross-sectional nature of our analyses. By focussing on ninth graders' occupational aspirations, we can only provide a snapshot of the association between personality traits and STEM aspirations. However, Coenen and colleagues (2021) assumed that the influence of personality on occupational preferences would decrease and the influence of cognitive skills on occupational preferences would increase in the course of secondary schooling. Therefore, we need more longitudinal analyses on how STEM aspirations translate into actual choices of STEM majors and whether young adults work in STEM occupations later on. Considering the timing of influencing factors, future research at this point may provide a valuable contribution to explaining the transformation of STEM preferences into STEM decisions.

Future directions
Finally, our results demonstrate that personality traits are better suited to differentiating pupils with Non-STEM aspirations from those not able to state an occupational aspiration yet. As Stefani and colleagues (2021) have shown, occupational aspirations in Germany are subject to substantial changes during secondary school, and only a small proportion of aspirations remain constant until pupils make a final decision on a particular major. It is evident that a large proportion of students have not yet formed a final occupational aspiration (the "Do not know" category) and the shares within the STEM domains do not reflect actual enrolment shares of process-produced data. This becomes even more relevant considering the unusually small tech-gender gap in grade nine, which, according to Stefani and colleagues (2021), increases sharply with enrolment into higher education, especially due to male students who previously showed no aspirations. While the volatility of occupational interests means the point-in-time measures have only limited explanatory power, future research should address this circumstance by looking sequentially at the relevance of personality throughout the educational trajectory from aspiration to subject choice.

All in all, based on a relatively large and representative dataset, our study shows that an explanation centering on personality traits complements previous explanations for STEM aspirations at the individual, social, and contextual level. In particular, personality traits might be useful for understanding young women's gender-atypical choices, since these are more difficult to understand than preferences in line with gender stereotypes. In this regard, the opposite effects for both subdomains – stronger personality traits make science aspirations less likely and technology aspirations more likely – paves the way for future research. Moreover, our results stress the importance of using a disaggregated STEM definition and applying separate analyses for girls and boys, especially in the case of Germany, where early occupational aspirations are highly consequential for future employment trajectories.

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ENDNOTES

[1] Occupational aspirations provide information about young women's and men's subjective individual desires to attain future educational and labor market outcomes. Realistic occupational aspirations (also often called occupational expectations) are defined by Morgan (2006, p. 1528) as students' "(…) stable prefigurative orientations composed of specific beliefs about one's future trajectory through the educational system and one's ultimate class or status position."

[2] In defining STEM occupations as academic occupations, we follow the definition of the European Commission (EU Skills Panorama, 2014, p. 1), which limits the STEM workforce to "people with a tertiary-education level degree in the subjects of science, technology, engineering and math" and is also similar to the definition of the OECD (OECD & Statistical Office of the European Communities, 1995). By doing so, we seek to ensure the international comparability of our STEM definition, yet at the expense of explicitly excluding occupations in STEM requiring an apprenticeship such as engineering technicians or machinists.

[3] There is also evidence concerning small variations regarding the general stability (see Costa et al. (2001) or Grönlund and Magnusson (2018)). According to Costa and colleagues (2001), gender differences in Neuroticism and Agreeableness, for example, are more distinct for adults than for students at college age, while gender differences in Extraversion and Openness decrease with age. At the same time, gender differences are greater in individualistic countries like Germany.

[4] Korpershoek et al. (2012) used the Five-Factor Personality Inventory (FFPI) by Hendriks et al. (1999) and investigated "Autonomy" instead of "Openness".

[5] This paper uses data from the National Educational Panel Study (NEPS; see Blossfeld et al. (2019)). NEPS is carried out by the Leibniz Institute for Educational Trajectories (LIfBi, Germany) in cooperation with a nationwide network.

[6] However, since the NEPS SC4 data did not differentiate between different tracks within comprehensive schools, we had to include all pupils attending this school type in our analytical sample. Therefore, our sample also includes pupils attending lower tracks in comprehensive schools, who might be less likely to develop

academic STEM preferences. Yet, we consider this less problematic since we assume that, within comprehensive schools, upward track mobility is more easily achieved than between school tracks, coming along with more academic occupational aspirations. To check the robustness of this assumption, we also estimated our models only with pupils attending the Gymnasium.

[7] Detailed coding procedures are available from the authors upon request.

[8] We only used one measure of missing values, which combined specific "I don't know" answers with unclear statements and other missing categories. We checked the robustness of this approach by merely including those with explicit "I don't know" answers.

[9] Scale reliability coefficient rises from 0.9894 to 0.9928.

[10] Unemployed parents are given the status 0.

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APPENDIX

Appendix A

Descriptive statistics for total, girls and boys

	Total		Girls		Boys	
	Mean / Share	*SD*	Mean / Share	*SD*	Mean / Share	*SD*
Girls	0.54					
Occupational aspirations						
Math/Science (MaSc)	0.02		0.01		0.03	
Technology/Engineering (Tech)	0.05		0.04		0.07	
Non-STEM	0.51		0.55		0.47	
Do not know	0.42		0.40		0.44	
Big Five traits						
Extraversion	3.46	0.90	3.50	0.90	3.42	0.89
Agreeableness	3.43	0.66	3.51	0.64	3.33	0.67
Conscientiousness	3.07	0.88	3.26	0.84	2.86	0.87
Neuroticism	2.75	0.87	2.93	0.83	2.55	0.86
Openness	3.53	0.97	3.73	0.92	3.32	0.97
Parental controls						
Importance of grades	4.27	0.85	4.22	0.84	4.33	0.85
STEM occupation father	0.08		0.08		0.08	
STEM occupation mother	0.02		0.02		0.02	
Socio-economic status [ISEI-08]	55.26	23.54	55.15	23.24	55.39	23.88
Migration background dummy	0.26		0.27		0.24	
Individual-level controls						
Year of birth	1995	0.64	1995	0.62	1995	0.66
Reading competences	0.52	1.18	0.64	1.18	0.40	1.16
Math competences	0.62	1.27	0.36	1.21	0.90	1.28
Science competences	0.43	0.98	0.32	0.96	0.56	0.98
ICT competences	0.42	0.90	0.39	0.87	0.45	0.94
Self-concept German	2.99	0.62	3.10	0.58	2.87	0.64
Self-concept math	2.55	0.93	2.34	0.90	2.77	0.90
Realistic aspiration for Abitur	0.73		0.72		0.73	
Observations	6,194		3,314		2,880	

Appendix B

Average marginal effects of girls' occupational aspirations (N=3,170; weighted; imputed)

	MaSc	Tech	Non-STEM	Do not know
Extraversion	-0.003 (-1.25)	0.011* (2.22)	0.030** (3.02)	-0.039*** (-3.70)
Agreeableness	-0.002 (-0.54)	0.003 (0.59)	-0.001 (-0.05)	-0.001 (-0.04)
Conscientiousness	-0.005* (-2.01)	0.005 (1.31)	0.018 (1.56)	-0.018 (-1.52)
Neuroticism	-0.003 (-1.11)	0.005 (1.27)	-0.006 (-0.53)	0.004 (0.30)
Openness	-0.001 (-0.71)	0.011* (2.43)	0.015 (1.27)	-0.025* (-2.27)
Year of birth	-0.000 (-0.02)	-0.010 (-1.71)	-0.019 (-1.31)	0.029* (2.12)
Self-concept math	0.007** (2.97)	0.003 (0.74)	-0.003 (-0.26)	-0.007 (-0.57)
Self-concept German	0.000 (0.13)	-0.018** (-3.13)	0.055** (3.18)	-0.038* (-2.14)
Realistic aspiration for Abitur qualification	0.002 (0.36)	0.036** (2.75)	-0.067* (-2.45)	0.029 (1.04)
Science competence	0.001 (0.26)	0.008 (1.54)	-0.019 (-1.39)	0.011 (0.78)
Math competence	-0.001 (-0.60)	-0.000 (-0.02)	-0.030* (-2.56)	0.032** (2.78)
ICT-literacy	0.002 (0.62)	0.014** (2.82)	0.006 (0.36)	-0.021 (-1.30)
Reading competence	0.004 (1.75)	-0.005 (-1.35)	0.004 (0.36)	-0.003 (-0.24)
Importance of grades for parents	0.002 (0.86)	0.004 (0.91)	0.005 (0.49)	-0.012 (-1.20)
Migration background dummy	-0.009 (-1.39)	0.012 (1.61)	0.011 (0.50)	-0.014 (-0.61)
STEM occupation father	-0.001 (-0.11)	0.001 (0.09)	-0.027 (-0.71)	0.026 (0.72)
STEM occupation mother	-0.190*** (-6.17)	0.012 (0.45)	0.096 (1.41)	0.082 (1.11)
Socio-economic status [ISEI-08]	0.000 (1.11)	-0.000 (-1.04)	0.000 (0.18)	-0.000 (-0.03)

Note. t statistics in parentheses. $^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.

Appendix C

Average marginal effects of boys' occupational aspirations (N=2,732; weighted; imputed)

	MaSc	Tech	Non-STEM	Do not know
Extraversion	-0.004	0.004	0.032*	-0.032**
	(-0.96)	(0.57)	(2.53)	(-2.66)
Agreeableness	-0.004	-0.009	-0.001	0.013
	(-0.68)	(-1.20)	(-0.05)	(0.80)
Conscientiousness	0.004	-0.007	0.026	-0.023
	(1.01)	(-1.01)	(1.82)	(-1.80)
Neuroticism	-0.002	-0.010	0.013	-0.000
	(-0.57)	(-1.46)	(0.94)	(-0.02)
Openness	0.004	0.020***	-0.001	-0.023*
	(1.24)	(3.91)	(-0.09)	(-2.22)
Year of birth	-0.005	-0.000	-0.017	0.022
	(-0.77)	(-0.02)	(-1.04)	(1.27)
Self-concept math	0.003	0.038***	-0.026*	-0.014
	(0.63)	(5.61)	(-2.01)	(-1.14)
Self-concept German	-0.009	0.001	0.064***	-0.056***
	(-1.76)	(0.12)	(3.85)	(-3.42)
Realistic aspiration for Abitur qualification	0.024	0.056**	-0.147***	0.067*
	(1.84)	(2.84)	(-4.69)	(2.17)
Science competence	0.008*	-0.020**	-0.014	0.026
	(2.22)	(-2.69)	(-0.88)	(1.62)
Math competence	0.008*	0.009	-0.018	0.000
	(2.55)	(1.66)	(-1.49)	(0.01)
ICT-literacy	-0.005	0.005	0.011	-0.011
	(-0.98)	(0.71)	(0.70)	(-0.68)
Reading competence	0.004	-0.003	0.001	-0.002
	(1.51)	(-0.59)	(0.13)	(-0.17)
Importance of grades for parents	-0.004	0.001	0.018	-0.015
	(-1.02)	(0.10)	(1.47)	(-1.31)
Migration background dummy	-0.002	-0.024	0.028	-0.002
	(-0.27)	(-1.88)	(1.12)	(-0.07)
STEM occupation father	0.005	0.046**	-0.045	-0.006
	(0.43)	(2.97)	(-1.17)	(-0.15)
STEM occupation mother	-0.022	0.001	0.065	-0.044
	(-0.78)	(0.04)	(0.92)	(-0.61)
Socio-economic status [ISEI-08]	0.000	0.000	0.000	-0.000
	(0.12)	(0.97)	(0.27)	(-0.77)

Note. t statistics in parentheses. $^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.