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How predictive are sex and empathizing–systemizing cognitive style for entry into the academic areas of social or physical sciences?

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Abstract

Based on the Empathizing–Systemizing (E–S) theory, it was hypothesized that the underrepresentation of female students in the physical sciences and the underrepresentation of males in the social sciences relates to differences in E–S cognitive style between the sexes. This hypothesis was tested in 115 physical science students and 155 social science students from a university in the Netherlands. The students completed visuospatial tests and the systemizing quotient-revised (SQ-R) as measures for systemizing, and a Cartoon Prediction test and the empathy quotient (EQ) as measures for empathizing. Independent of sex, the physical science students scored significantly lower than social science students on EQ (with large effect size) and ‘brain type’ that represents the standardized difference score between EQ and SQ-R (with large effect size). Physical science students, furthermore, scored significantly higher on the Cartoon Prediction task and one of the visuospatial tasks; however, these effects were only small of size. Unlike the scores on the SQ-R and the performance tests, the ‘brain type’ score of the EQ and SQ-R questionnaires was a good predictor of entry into social or physical sciences. Interestingly, the typical sex differences in more empathizing and less systemizing in females compared to males were only small for EQ and ‘brain type’, and absent for the SQ-R and the performance tests. This study only partially confirms the E–S theory, because typical sex differences were only minor in this selective sample and only the self-report measures predicted academic area in the absence of a role for sex.

Keywords Empathy quotient (EQ) · Systemizing quotient (SQ) · Science, technology, engineering, and mathematics (STEM) · Gender differences · Things–people dimension · Cognitive style

Introduction

Women are underrepresented in the disciplines of science, technology, engineering, and mathematics (STEM), whereas men are underrepresented in the disciplines of social sciences and medical services (Su and Rounds 2015). In the Netherlands, the number of women in STEM majors did rise from 28% in 2002 to 39% in 2013, presumably because the government started stimulating the attraction of students for

this field in 2004, but still there is a persistent gender disparity in the STEM field, particularly in non-academic education (Platform Beta techniek 2014). The gender disparity in STEM fields has also been observed internationally, including Brazil (Correa Varella et al. 2016), the USA (National Science Foundation 2013), and Spain (Ministry of Education, Culture and Sport 2015). However, within specific STEM fields variation has been noticed in the gender composition. For example, relatively few women study mechanics/electronics or engineering compared to mathematics, natural or physical sciences (Su and Rounds 2015). One of the most important psychological mechanisms explaining this gender disparity (with)in STEM fields is that women and men have personality differences in vocational interests. These interests are classically measured by means of self-report personality scales that ask for the individual’s interest in specific activities and topics, covering a wide range of occupational areas. In general, vocational interests can be categorized into two bipolar dimensions: things–people and

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data–ideas (Prediger 1982; Su et al. 2009). The things–people dimension refers to preference for *non-personal* tasks (e.g. working with machines and gadgets) on the ‘things’ end of the dimension and preference for *interpersonal* tasks (e.g. working with and helping people, often in teams) on the ‘people’ end. The data–ideas dimension refers to preference for *impersonal* tasks (e.g. working with facts and systematic procedures) on the ‘data’ end of the dimension and preference for *intrapersonal* tasks (e.g. working with abstract ideas and expression) on the ‘ideas’ end. Large sex differences have particularly been found on the things–people dimension, with females typically favouring people-oriented tasks and males typically favouring things-oriented tasks (Halpern 2011, chapter 6; Su et al. 2009; Su and Rounds 2015). This might explain why more women opt for a ‘people-oriented’ career in non-STEM fields like social sciences and medical services containing people-oriented environments, and more men for a ‘things-oriented’ career in STEM fields containing things-oriented environments (Su and Rounds 2015; Woodcock et al. 2013).

A controversial question is to what extent these sex differences in interests for people versus things are based on sex differences in cognitive abilities. Decades of psychological research devoted to the question of sex differences in cognitive abilities has led to the conclusion that ‘there are sex differences in the brain, but that the brains of females and males are far more similar than they are different’ (Halpern 2011, p. 241). It has, for example, become clear that the differences between boys and girls in intrinsic aptitude for mathematics and science are complex and subtle (Spelke 2005), and that these differences are vulnerable to sex-differentiated patterns of socialization and training (Halpern 2011, p. 245). For example, boys may show greater variability in mathematical ability than girls so that more boys show extreme mathematical talent, but those male and female students entering a programme for advanced mathematics benefitted equally from training and were equally successful in such a programme (Spelke 2005). Also, some academic areas, e.g. veterinary medicine, that were previously dominated by males are nowadays dominated by females (Halpern 2011, p. 95). This demonstrates how socialization processes may influence cognitive abilities and choice of academic area. Generally, psychologists can be categorized into minimizers who endorse the view that sexes are mostly similar in cognitive abilities (and belief that socialization has the largest impact) and those who endorse the view that men and women are essentially dissimilar (Halpern 2011, pp. 6–7). Most psychologists, however, fall along the continuum between these standpoints, recognizing both biological differences and the impact of socialization processes (‘gender reality hypothesis’; Lippa 2006). The Empathizing–Systemizing (E–S) theory of sex differences (Baron-Cohen 2009) can be regarded as a maximizing theory, holding the rather

controversial view that male and female brains are essentially different and that men and women possess different cognitive styles that are due to biological differences.

The E–S theory may, however, provide an elegant explanation of the reason why women typically opt for people-oriented careers and men typically for things-oriented careers. It states that women have on average a stronger empathizing cognitive style, i.e. the capacity to analyse people/feelings, and men on average a stronger systemizing cognitive style, i.e. the capacity to analyse things/systems. The present study puts this theory to the test and investigates whether sex differences in systemizing and empathizing cognitive styles, also referred to as ‘brain type’ (Baron-Cohen et al. 2005), may explain why more men enter STEM fields (in this article shortly referred to as the physical sciences) and more females the social sciences. Even though a complex interplay of other factors such as sex differential socialization and training, career perspective, level of compensation, or personality is known to contribute to choice of major and career fields (Diekmann et al. 2010; Chen and Simpson 2015; Malgwi et al. 2005), the contribution of empathizing–systemizing cognitive style is understudied. Understanding the differences between men and women in cognitive style could contribute to the understanding of why they have different interests on the things–people dimension.

According to the Empathizing–Systemizing theory of sex differences, a typical male brain is best suited for *systemizing*, which is defined as a drive to analyse the variables in a system, to derive the underlying rules that govern the behaviour of a system, and to construct systems (Baron-Cohen 2002), i.e. the capacity to analyse things/systems. The systemizing cognitive style can be characterized by a consciousness of the physical world that can always be analysed in terms of logical input–operation–output patterns (Baron-Cohen 1999). In line with this proposition, sex differences in tasks that require visuospatial skills are among the largest sex differences reported in the scientific literature, with effect sizes ranging from medium to large. Many studies have demonstrated that men on average perform better than women on tasks that require systemizing skills, such as spatial navigation, mental rotation (Geiser et al. 2008b; Nazareth et al. 2013; Voyer et al. 1995), dynamic spatial tasks (Contreras et al. 2001), and mathematical problem-solving tasks (Kimura 2002). However, this field is also characterized by inconsistent findings, suggesting that environmental factors and experience with spatial activities contribute to minimizing or maximizing sex differences in visuospatial abilities (Contreras et al. 2012; Geiser et al. 2008a; Rodán et al. 2016).

A typical female brain would, according to the E–S theory, be best suited for *empathizing* which is defined as ‘the drive to identify another person’s emotions and thoughts and to respond to these with an appropriate emotion’

(Baron-Cohen 2002), i.e. the capacity to analyse people/feelings. The female brain type can be characterized by a consciousness of the mental world which is dominated by mental states as well as feelings (Baron-Cohen 1999). There is consistent evidence that women perform better than men on social cognition tasks requiring mindreading (Vellante et al. 2013), emotion recognition, and emotion expression (Kret and De Gelder 2012; Montagne et al. 2005; Sasson et al. 2010) with effect sizes in the small to medium range. A recent review underscored the presence of fundamental differences between males and females in performance measures for empathy that were deemed least influenced by gender stereotypes (Christov-Moore et al. 2014).

The vast amount of evidence for sex differences in brain type does, however, not come from performance tasks, but from the self-report questionnaires 'empathy quotient' (EQ) (Baron-Cohen and Wheelwright 2004) and 'systemizing quotient' (SQ) (Baron-Cohen et al. 2003) that may be more susceptible to gendered socialization and stereotypes. A recent literature review confirmed consistent sex differences across international studies on the EQ and SQ scores, with men scoring higher on the SQ and lower on the EQ than women as indicated by medium to large effects sizes (Groen et al. 2015). Sex differences in self-reported E–S cognitive style may predict why men and women tend to choose different fields of education. The field of physical sciences requiring a higher degree of understanding things/systems would likely attract systemizing brain types and thus more males, whereas social sciences requiring a higher degree of understanding people/feelings would likely attract more empathizing brain types and thus more females (Correa Varella et al. 2016). Indeed, few studies did not only find that physical science students scored higher on the SQ and lower on the EQ than students from social sciences, humanities, or biological sciences, but also that measures of systemizing and empathizing were better predictors of entry in physical and social sciences than sex (Billington et al. 2007; Correa Varella et al. 2016; Focquaert et al. 2007; Manson and Winterbottom 2012; Wheelwright et al. 2006). However, these former studies primarily made use of the self-report measures SQ and EQ. Only one study (Billington et al. 2007) additionally applied more implicit performance measures of systemizing and empathizing abilities, which can be deemed more independent from gender stereotypes. That study by Billington et al. (2007) provided evidence for a systemizing brain type in physical science students and an empathizing brain type for humanities students by using the EQ and SQ as well as the Embedded Figures Task (assessing systemizing) and the Eyes test (assessing empathy). Moreover, brain type assessed by EQ–SQ appeared to be the strongest predictor of academic area, followed by the performance on the

Embedded Figures Task, the performance on the Eyes test, and lastly by sex that appeared the least critical factor in this prediction.

The present study aimed to directly test the E–S theory by examining the typical sex differences and the typical differences between physical science and social science students in their E–S cognitive style. A second aim was to examine whether E–S cognitive style is a predictor of entry into physical or social sciences, when controlling for sex. The E–S theory predicts the typical sex differences on both self-report and performance measures of empathy (female superiority) and systemizing (male superiority), and that E–S cognitive style would be valid predictors of entry into the social or physical sciences. Unlike most previous studies, next to self-report measures also performance measures were included. The added value of performance measures is that they are less influenced by gendered socialization and stereotypes than self-report measures. Finding sex or faculty differences in performance measures would therefore be more indicative of fundamental biological differences than differences in self-reported cognitive style.

Methods

Participants

Two groups of students were recruited from the University of Groningen, The Netherlands. The first group consisted of 115 students (63 males) from the Faculty of Mathematics and Natural Sciences and studied one of the following subjects: Applied Mathematics, Biology, Chemical Engineering, Chemistry, Computing Science, Life Science and Technology, Mathematics, Physics, Pharmacy, or Industrial Engineering and Management. The second group consisted of 155 students (65 males) from the Faculty of Behavioural and Social Sciences and studied Theory of Education, Educational Sciences, Psychology, or Sociology. The students were aged 17–43 years ($M = 21$, $SD = 3.4$) and studied their subject for 1–6 years ($M = 2$). The physical science students studied their topic somewhat longer than the social science students (2 vs. 1.7 years; $F(1267) = 5.1$, $p = .024$), but they did not differ in age. The participants were recruited in public spaces at the respective faculties and the university library by randomly asking students to participate. Eighty-five social science students were recruited via a research participants pool of the Department of Psychology and earned study credits for participation. The study was approved by the Ethical Committee of Psychology of the University of Groningen. Informed consent was obtained from all individual participants included in the study.

Procedure

Before starting the assessment of 45 min, the participants read a fact sheet about the study and signed informed consent. For assessment, the participant was seated at a table in a quiet place. First a test assistant assessed the performance tests, and afterwards, the EQ and SQ-R were completed.

Materials

Cartoon Prediction test

A paper-and-pencil Cartoon Prediction test was applied that had been adopted from a social intelligence test battery (O'Sullivan and Guilford 1976), measuring the ability of 'social judgement'. This test is assumed to measure empathy, because the accurate prediction of the social consequences in the cartoons relies on the inference of mental states from the characters in the cartoons. The Cartoon Prediction test is sensitive for deficits in patients with social disabilities including frontotemporal dementia and psychosis (Eslinger et al. 2007; Montreuil et al. 2010), and correlates with second-order theory of mind ability, non-social executive resources, and atrophy in areas that are involved in the social brain (Eslinger et al. 2007). During the test, 30 cartoons are presented depicting interpersonal situations (Fig. 1). The participants were instructed to choose one out of three alternative cartoons showing what most likely follows the situation depicted in the first cartoon, based on the thoughts, feelings, and intentions of the characters. The participants had 4 min for completing the first 15 items, followed by a break, and another 4 min for the second 15 items. The performance was scored as the total number of correct items, with a maximum score of 29 (according to the test manual, one item was omitted from the scoring).

Fig. 2 Practice items for each of the included subtests of the Leistungsprüfsystem (printed with permission by Hogrefe Verlag, Göttingen, Germany), measuring **a** mental rotation: 'strike through the mirrored number or letter', **b** spatial aptitude: 'strike through the letter appearing on the spot of the number when you would fold it', **c** spatial aptitude: 'strike through the number that corresponds to the number of sides of the figure', and **d** central coherence: 'strike through the shape (as shown above) that can be found in the geometrical patterns'

Fig. 1 Practice item for the Cartoon Prediction test (printed with permission by Consulting Psychologists Press); the participant had to predict which picture most likely followed the first picture of the

cartoon by attending to the thoughts, feelings, and intentions of the characters; the correct answer in this item is 1

Visuospatial test

Four paper-and-pencil visuospatial subtests were performed that had been adopted from a German performance test called Leistungsprüfungssystem (LPS; Horn 1983) (Fig. 2). The subtests measured mental rotation (MR), spatial aptitude (SA-1 and SA-2), and central coherence (CC). The participants were presented with a print of the tests and were instructed for each subtest to complete as many items in a given time that was kept by the instructor with a stopwatch (MR: 2 min.; SA-1: 4 min.; SA-2 and CC: 3 min.). The performance was scored as the number of correct items for each subtest as well as the number of correct items for the total test. The maximum score for each test was 40 with a total test maximum of 160.

Empathy quotient (EQ)

A paper version of the Dutch EQ (40 items plus 20 filler items) was completed (Groen et al. 2015). Participants were requested to rate on a four-point Likert scale to what extent they agreed or disagreed with the presented items. The 28-item scoring system was used, because the reliability of this abridged version has been found to be higher than of the 40-item version (Groen et al. 2015). Furthermore, this version allows the computation of the subscales ‘cognitive empathy’ (CE), ‘emotional empathy’ (EE), and ‘social skills’ (SS). The 18 forward items (1, 6, 19, 22, 25, 26, 35, 36, 41, 42, 43, 44, 52, 54, 55, 57, 58, and 59) were scored 2 for ‘strongly agree’, 1 for ‘slightly agree’, and 0 for ‘strongly disagree’ and ‘slightly disagree’. The 10 reversed items (4, 8, 12, 14, 21, 27, 29, 32, 48, and 50) were scored 2 for ‘strongly disagree’ and 1 for ‘slightly disagree’, and 0 for ‘strongly agree’ and ‘slightly agree’. The maximum score on the 28-item EQ was 56.

Systemizing quotient- revised (SQ-R)

A paper version of the Dutch SQ-R (75 items) was applied (Groen et al. 2015). The items were rated on a four-point Likert scale (strongly agree, slightly agree, slightly disagree, and strongly disagree). The 36 reversed items (3, 6, 8, 10, 15, 17, 22, 24, 26, 28, 31, 33, 34, 35, 37, 39, 40, 44, 45, 47, 48, 49, 51, 52, 54, 56, 57, 58, 59, 63, 64, 65, 67, 70, 71, and 73) were scored 2 for ‘strongly disagree’ and 1 for ‘slightly disagree’, and 0 for ‘strongly agree’ and ‘slightly agree’. In contrast, the remaining 39 forward items were scored 2 for ‘strongly agree’ and 1 for ‘slightly agree’, and 0 for ‘strongly disagree’ and ‘slightly disagree’. The maximum score on the SQ-R was 150.

Brain type (*D*)

Based on the EQ and SQ-R scores, the participant’s brain type (*D*) score was calculated. First, the scores

were standardized according to the Dutch norms (Groen et al., 2015) using the formulas: $E = (EQ - 33.1)/56$ and $S = (SQ-R - 54.3)/150$. Secondly, the continuous measure for brain type was calculated by the formula $D = [(S - E)/2]$ (Wheelwright et al. 2006). The lowest possible score was -0.385 indicating an extreme empathizing cognitive style, and the highest possible score was 0.615 indicating an extreme systemizing cognitive style.

Statistical analyses

A 2*2 ANOVA analysis with the between subjects factors ‘sex’ (female vs. male) and ‘faculty’ (physical sciences vs. social sciences) was conducted for all test scores. To test predictors of entry into physical or social sciences, a multiple binary logistic regression was performed with ‘faculty’ (physical sciences (coded as 0) vs. social sciences (coded as 1)) as the binary outcome measure, sex as a covariate (block 1) and the total scores on the Cartoon Prediction test, LPS, EQ, SQ-R and *D* as predictors using the forward method (block 2).

A receiver operating characteristic (ROC) analysis was computed for significant predictors in the logistic regression model. ROC analysis was performed in order to explore the accuracy of the measures in distinguishing between physical and social science students. A ROC curve is a graphical plot of sensitivity versus ‘1 – specificity’ at each level of the scale under scrutiny to predict the criterion (distinguishing physical from social science students). ROC analysis allows for determination of an overall accuracy of classification as measured by the area under the curve (AUC), as well as classification statistics to address specific goals, i.e. high sensitivity or high specificity.

Results

Effects of sex and faculty

Table 1 presents the test scores of the physical and social science students for empathy and systemizing, and Fig. 3 provides a graphical overview. Across faculties, only significant sex differences were found for the EQ, the EE subscale of the EQ and *D* with females scoring higher on empathic traits than males (Table 2), and effect sizes ranging from negligible (*D*) to medium (EE scale). When comparing the faculties, however, the social science students reported considerably more empathic traits on the EQ and all its subscales as well as a more empathizing brain type than physical science students. These differences represented large effects (Cohen’s $d > 1$). Furthermore, the physical science students scored higher than the social science students on the Cartoon Prediction task and the LPS task *D* (central coherence). These differences, however, were only of small size (Cohen’s $d < 0.3$). No sex or faculty

Table 1 Means and standard deviations of the empathy and systemizing measures in male and female students from the physical and social sciences

	Physical sciences (<i>n</i> = 115)		Social sciences (<i>n</i> = 155)	
	Females (<i>n</i> = 52)	Males (<i>n</i> = 63)	Females (<i>n</i> = 90)	Males (<i>n</i> = 65)
	<i>M</i> (SD)	<i>M</i> (SD)	<i>M</i> (SD)	<i>M</i> (SD)
Cartoon Prediction	21.6 (3.4)	20.7 (3.8)	20.3 (3.7)	20.2 (3.1)
LPS total	119.3 (7.7)	121.3 (17.3)	116.7 (18.5)	116.3 (19.0)
LPS MR	21.9 (7.5)	21.5 (6.3)	20.8 (7.9)	21.6 (7.7)
LPS SA-1	35.0 (6.4)	35.5 (5.5)	34.7 (7.2)	33.9 (8.1)
LPS SA-2	28.9 (5.3)	30.7 (5.7)	28.9 (5.1)	29.6 (5.0)
LPS CC	33.5 (5.8)	33.5 (6.4)	32.2 (5.4)	31.3 (6.6)
EQ total	21.0 (15.3)	17.2 (11.9)	37.0 (7.9)	32.7 (8.8)
EQ CE	8.4 (7.0)	6.8 (6.2)	14.3 (4.4)	13.7 (4.5)
EQ EE	9.1 (6.7)	7.1 (4.4)	15.5 (3.5)	13.0 (4.4)
EQ SS	3.7 (3.0)	3.4 (2.9)	7.7 (2.1)	6.8 (2.4)
SQ-R total	56.6 (17.9)	56.8 (17.7)	51.0 (16.8)	55.9 (16.3)
<i>D</i> (brain type)	0.115 (0.130)	0.150 (0.083)	− 0.046 (0.088)	0.009 (0.091)

LPS leistungsprüfssystem, *MR* mental rotation task, *SA-1* spatial aptitude task 1, *SA-2* spatial aptitude task 2, *CC* central coherence task, *EQ* empathy quotient, *CE* cognitive empathy, *EE* emotional empathy, *SS* social skills, *SQ-R* systemizing quotient-revised

Fig. 3 Bar charts of the mean scores on the empathy and systemizing measures separated for male and female students from the physical and social sciences; Error bars represent standard errors; LPS = leistungsprüfssystem; EQ = empathy quotient; SQ-R = systemizing quotient-revised; *D* = brain type. Note that the LPS score was divided by 10, and the *D* score was multiplied by 100 in order to fit the scale

effects were found for SQ-R. No significant Sex*Faculty interaction effects were present (all *p* values > .05).

Predicting entry into physical or social sciences

The logistic regression with sex as a covariate (with females as the reference category) and five predictors (LPS total, Cartoon Prediction, EQ total, SQ-R total and *D*) revealed two models that were statistically significant (Table 3). In the first model, *D* significantly predicted to which faculty a student belonged when controlling for sex (Chi-square = 125.8, *p* < .001, *df* = 2, Nagelkerke R^2 = .50). In the second model, the Cartoon Prediction test was included as well, but this model did only explain little additional variance compared to the first model (Chi-square = 131.5, *p* < .001, *df* = 3, Nagelkerke R^2 = .52). Both models, however, explained more

variance than a model including sex only (Chi-square = 4.4, *p* < .05, *df* = 1, Nagelkerke R^2 = .02).

We also tested the model excluding the Brain type index (*D*) so that the 'pure' contribution of EQ and SQ-R could be quantified (i.e. including the four predictors LPS total, Cartoon Prediction, EQ total, and SQ-R total). Most of the variance in the predictive model was explained by EQ (in terms of Nagelkerke R^2 45%). However, adding the SQ-R did improve the model with an additional 6% of variance (in terms of Nagelkerke R^2) and more students were classified into the correct academic area. This fits the finding that faculty differences on *D* were larger than on the EQ only. The model only including EQ had a worse fit than the model including both EQ and SQ-R, and the model including both EQ and SQ-R had a similar fit as the model including the Brain type index only. Even though the contribution of SQ-R

Table 2 Test results of the two-way ANOVA with the factors 'sex' (females vs. males) and 'faculty' (physical sciences vs. social sciences)

	Sex effect $F(1266) =$	Faculty effect $F(1266) =$	Sex*faculty interaction $F(1266) =$
Cartoon Prediction	1.4, $p = .230$, $d = 0.11$	4.5, $p = .036^*$, $d = 0.23$	0.7, $p = 0.409$
LPS total	0.1, $p = .718$, $d = 0.07$	2.8, $p = .097$, $d = 0.22$	0.3, $p = .601$
LPS MR	0.1, $p = .801$, $d = 0.05$	0.3, $p = .595$, $d = 0.07$	0.4, $p = .507$
LPS SA-1	0.0, $p = .831$, $d = 0.03$	1.2, $p = .268$, $d = 0.13$	0.6, $p = .433$
LPS SA-2	3.5, $p = .062$, $d = 0.23$	0.8, $p = .381$, $d = 0.13$	0.8, $p = .366$
LPS CC	0.4, $p = .544$, $d = 0.04$	5.4, $p = .020^*$, $d = 0.28$	0.5, $p = .477$
EQ total	9.1, $p = .003^{**}$, $d = 0.46$	136.6, $p < .001^{***}$, $d = 1.44$	0.4, $p = .842$
EQ CE	2.6, $p = .106$, $d = 0.30$	89.3, $p < .001^{***}$, $d = 1.17$	0.5, $p = .493$
EQ EE	15.7, $p < .001^{***}$, $d = 0.56$	114.3, $p < .001^{***}$, $d = 1.32$	0.2, $p = .628$
EQ SS	3.1, $p = .077$, $d = 0.31$	128.5, $p < .001^{***}$, $d = 1.38$	0.9, $p = .346$
SQ-R total	1.4, $p = .234$, $d = 0.19$	2.4, $p = .124$, $d = 0.22$	1.2, $p = .269$
D (brain type)	13.7, $p < .001^{***}$, $d = 0.12$	156.7, $p < .001^{***}$, $d = 1.56$	0.7, $p = .398$

LPS leistungsprüfsystem, MR mental rotation task, SA-1 spatial aptitude task 1, SA-2 spatial aptitude task 2, CC central coherence task, EQ empathy quotient, CE cognitive empathy, EE emotional empathy, SS social skills, SQ-R systemizing quotient-revised

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3 Binary logistic regression model with predictors of entry into physical and social sciences

Variable	β	SE	Odds ratio	Wald statistic
Step 0				
Sex	0.3	0.1	1.3	5.9*
Step 1				
Sex	-0.5	0.3	1.5	4.3*
D (brain type)	-15.9	2.0	0.0085	63.7***
Step 2				
Sex	0.4	0.35	1.5	1.2 ^{ns}
D (brain type)	-16.2	2.0	0.0085	63.1***
Cartoon Prediction	-0.1	0.04	0.9	5.4*

Sex was entered as a covariate with females as the reference category (female = 1 and male = 0)

* $p < .05$, ** $p < .01$, *** $p < .001$, ^{ns} $p > .05$

was not large, it improved correct classification, and therefore, we chose to use the Brain type index (instead of EQ only) as the best explanation for faculty differences.

Defining a cut-off score

Figure 4 presents the graphical plot of the ROC analysis. D significantly distinguished social science students from physical science students with good classification accuracy (AUC = .858; SE = .024; $p < .001$), which was slightly better in males (AUC = .871; SE = .031; $p < .001$) than in females (AUC = .834; SE = .038; $p < .001$). The classification statistics for various cut-offs of D are presented in Table 4, and inspection of this table reveals an optimal

Fig. 4 ROC curve of D (brain type) score for distinguishing social science from physical science students

cut-off criterion at $D = 0.09$ (systemizing) for males and $D = 0.02$ (balanced, nearly systemizing) for females. These cut-off scores represent the most optimal combination of sensitivity and specificity for predicting membership of the faculties. Using the cut-off for males, 82% of the students could correctly be assigned to the physical science faculty and 84% to the social science faculty. For females, these predictive values were somewhat lower, with 78% correctly being assigned to the physical science faculty and 75% to the social science faculty.

Table 4 Classification accuracy of brain type (*D*) in distinguishing social science students ($n = 155$) from physical science students ($n = 115$) for males and females

Brain type	Cut-off	Females				Males			
		Sens.	Spec.	PPV	NPV	Sens.	Spec.	PPV	NPV
<i>B</i>	− 0.02	82.7	61.1	55.1	85.9	95.2	36.9	59.4	88.9
<i>B</i>	− 0.01	80.8	65.6	57.5	85.5	95.2	44.6	62.5	90.6
<i>B</i>	0.00	78.8	70.0	60.3	85.1	92.1	46.2	62.4	85.7
<i>B</i>	0.01	75.0	71.1	60.0	83.1	92.1	50.8	64.4	86.8
<i>B</i>	0.02 ^F	75.0	77.8	66.1	84.3	90.5	53.8	65.5	85.4
<i>S</i>	0.03	71.2	82.2	69.8	84.1	88.9	55.4	65.9	83.7
<i>S</i>	0.04	69.2	87.8	76.6	83.2	88.9	58.5	67.5	84.4
<i>S</i>	0.05	67.3	90.0	79.5	82.7	87.3	67.7	72.4	84.6
<i>S</i>	0.06	65.4	92.2	82.9	82.2	87.3	70.8	74.3	85.2
<i>S</i>	0.07	63.5	92.2	82.5	81.4	84.1	73.8	75.7	82.8
<i>S</i>	0.08	57.7	93.3	83.3	79.3	84.1	76.9	77.9	83.3
<i>S</i>	0.09 ^M	55.8	95.6	87.9	78.9	84.1	81.5	81.5	84.1
<i>S</i>	0.10	53.8	96.7	90.3	78.4	81.0	83.1	82.3	81.8
<i>S</i>	0.11	50.0	96.7	89.7	77.0	73.0	86.2	83.6	76.7
<i>S</i>	0.12	46.2	97.8	92.3	75.9	66.7	87.7	84.0	73.1

The optimal cut-off scores for females and males are indicated by ^F and ^M, respectively

F most optimal cut-off score for females, *M* most optimal cut-off score for males, *Sens.* sensitivity, *Spec.* specificity, *PPV* positive predictive value, *NPV* negative predictive value, *B* balanced, *S* systemizing

Discussion

The present study was undertaken to test the hypothesis that the underrepresentation of female students in the physical sciences (STEM fields) and the underrepresentation of males in the social sciences relates to differences in E–S cognitive style between sexes. The first aim was to replicate the typical sex differences, and the typical differences between physical science and social science students in their E–S cognitive style. Positive findings for both self-report and performance measures would be in line with the E–S theory of sex differences as formulated by Baron-Cohen (2009). However, in contradiction to the predictions of this theory, typical sex differences were only found for the EQ with small effect size (female superiority) and brain type with negligible effect size (more empathizing brain type in females). No typical sex differences were found for the SQ-R or for the performance tasks of empathy and systemizing. The observed sex differences on EQ and brain type were smaller than the usually reported medium to large effects in broad samples from Western countries (see Groen et al. 2015). This can be explained by the highly selective samples used in the present study, i.e. students from either physical or social sciences, and these findings should therefore not be generalized to the total population. In both faculties, sex differences were small to negligible (no interactions of sex by faculty), which may be related to similar vocational interests and training in males and females within each faculty. Our data are therefore only partially supportive of the E–S theory of sex differences and are more in line with gender similarity or gender reality

hypotheses of sex differences. These assume that biological differences between men and women in cognitive abilities are only minimal, which may be enhanced (or reduced) by gendered socialization and stereotypes (Halpern 2011; Spelke 2005; Lippa 2006). However, self-reported E–S cognitive style had good predictive validity for membership of academic area, independent of sex. Those students scoring systemizing brain type were likely to be enrolled in the physical sciences, and students with a balanced or empathizing brain type were likely to be enrolled in the social sciences (see Fig. 5 for a graphical impression of the brain type distribution across faculties). The skewed distribution of brain types across males (more males with systemizing brain type) and females (more females with empathizing brain type) in the general population (Groen et al. 2015) may explain the internationally observed underrepresentation of females in the STEM fields and underrepresentation of males in the social sciences and health services. Interestingly, this conclusion can only be drawn for the self-reported E–S cognitive style, as no typical sex differences or practically relevant faculty differences were found for the performance tasks of empathy and systemizing.

Many previous studies using broader samples did confirm typical sex differences on E–S measures. Female superiority in empathy has been supported, not only on self-reports of the EQ (Groen et al. 2015), but also on implicit measures that are more free from gendered socialization and stereotypes, e.g. females show more prosocial behaviour, higher emotional responsivity, and better emotion recognition than males (Christov-Moore et al. 2014). Currently, a pattern is

Fig. 5 Histogram brain type distribution across the social science and physical science faculties

emerging from the neuroscientific literature that females particularly have an advantage in the more emotional and automatic aspect of empathy (affective empathy), but that sex differences are minimal for the more controlled and reasoned aspect empathy, including perspective taking and mentalizing (cognitive empathy) (see for a detailed review Christov-Moore et al. 2014). The measure for empathy in the current study, the Cartoon Prediction test, requires a logical ‘input–operation–output’ reasoning about the social interactions depicted in the cartoons, while taking basic emotions and expressions in cartoon figures into account. This can be regarded a typical cognitive empathy task which may explain why it was not sensitive for detecting sex differences. Billington et al. (2007) who performed a similar study did find the typical sex (as well as faculty) differences for a more affective measure of empathy: the Eyes test. The Eyes test requires insight into complex emotions and expressions that can be read in the eyes of photographs of real people (for an overview of this test, see Vellante et al. 2013). The low load on affective empathy may therefore explain why the Cartoon Prediction test used in the present study failed to reveal sex differences. Future studies should therefore include more measures of empathy to gain insight into the different aspects of empathy that are involved.

Many previous studies have also supported a male superiority in tasks that require systemizing, by self-report (Groen et al. 2015) and by skill (Geiser et al. 2008b). Our data could not replicate this finding as the sexes did neither differ in their self-ratings of systemizing (SQ-R) nor in their accuracy on four visuospatial tasks (LPS). Particularly, the null finding on the mental rotation task was striking, as quite consistent sex differences with effect sizes in the medium to

large range have been reported in the literature (Geiser et al. 2008b). Surprisingly, some recent articles also could not replicate sex differences in mental rotation task performance (Rodán et al. 2016). An interesting hypothesis put forward by Rodán et al. (2016) regarding this recent trend is that both sexes in the current information- and technology-driven society get more equal training with visuospatial tasks, by using smartphones, apps, and games, unlike years ago when it was mostly boys who played video games. This would mean that previously found sex differences on visuospatial tasks were at least in part due to gendered training. The majority of students included in the present study were in their young twenties and born and raised in an era of digital technology. This could have contributed to more equal training of visuospatial tasks between sexes, which might have reduced the typical sex differences that were observed in the past. Both our performance and our self-reported systemizing data are in line with this hypothesis, but longitudinal research of broader samples is necessary to confirm this. In this regard, it would also be important to take other societal trends into account, such as more equal gender roles regarding the household and child care in Western countries. In a similar manner, it could be speculated that sex differences on empathy tasks are partly due to gendered training for caring tasks.

Despite the limited evidence for sex differences in E–S cognitive style, students from the physical sciences and students from the social sciences could be distinguished very accurately based on self-reports of E–S cognitive style. As predicted, the physical science students scored lower than social science students on EQ (on all subscales with large effect sizes) and brain type (with large effect size). The brain type score appeared to be a good predictor of entry into social or physical science, whereas being male or female only contributed very little to this prediction (see Fig. 5 and Table 3). Entry into physical sciences could be predicted by brain type score with 87% accuracy for males and 83% for females (based on AUC values). This converges with previous findings by Billington et al. (2007) that also indicated that brain type was the best predictor of entry into physical sciences, more so than sex and test performance on tasks measuring empathy and systemizing. Previous work by Contreras et al. (2012) also found no role of sex in the prediction of performance of dynamic spatial tasks, whereas lower level cognitive processes did. Our findings suggest that the EQ in combination with SQ-R could be included as assessment tools for choice of major. In this respect, a brain type cut-off criterion of above 0.09 (systemizing) for males and above 0.02 for females (balanced, nearly systemizing) would guide recent graduates towards a study in the physical sciences, as our data show that physical science students tend to score systemizing brain types. It must be noted that this prediction is slightly less accurate in females than in males,

and that, especially within the social sciences females, had a larger variance of brain types (as indicated by the PPV of 66%). It remains to be tested to what extent the E–S cognitive styles complement to the more classical personality scales that are used for assessments of career choice. Particularly, the relationship with the people–things dimension is relevant in this context (Prediger 1982; Su et al. 2009). The E–S cognitive styles may strongly correlate with positive attitudes towards (and interest in) the ‘people-oriented’ social sciences or the ‘things-oriented’ physical sciences. Future studies on the determinants of choosing major could include measures of Empathizing and Systemizing in their prediction models, even though our understanding of the stability of these measures over the years (with learning, practice and training) and their relation to study success in specific programmes should be increased. Furthermore, future studies should cover more study fields, including a broader range of STEM fields, biomedical fields, health services, and humanities. A potentially confounding factor that should be taken into account in further studies is sexual orientation, because there is some evidence that homosexual individuals may have occupational interests that are more similar to the opposite sex than to their own sex (Ellis et al. 2012).

The systemizing measures had hardly any predictive validity for academic area. This is not in line with previous studies showing higher SQ scores per se in physical science students as compared to social science or humanities students with small to medium effect sizes (Billington et al. 2007; Focquaert et al. 2007; Manson and Winterbottom 2012; Wheelwright et al. 2006). Also a measure of central coherence has previously been shown to have predictive value for academic area (Billington et al. 2007). One explanation for the lacking sensitivity of purely systemizing measures could be the selection of the present sample. The Faculty of Behavioural and Social Sciences at the University of Groningen emphasizes statistical methodology and biology in their education, which might have attracted the relatively systemizing skilled students compared to students from humanities, e.g. languages, arts, philosophy, who were also included in previous studies. Another explanation of the lacking sensitivity of systemizing as assessed by visuospatial tests could be that the tests applied in the present study measure basic visuospatial skills. These basic visuospatial skills are not comparable to the complexity of the systems and problems studied in the physical science field. However, in the present study as well as the study by Billington et al. (2007) a test measuring central coherence (the Embedded Figures test) was performed better by physical science students than social and humanities science students (with small effect sizes). Although central coherence was not a good predictor of entry into the different faculties in the present study, Billington and colleagues could successfully differentiate between students

from physics and humanities. Unfortunately, the magnitude of this effect remains unclear.

Our data support the conclusion that social and physical science students (either male or female) strongly differ in their self-reported cognitive style, but that they do not substantially differ on performance measures of empathy and systemizing. The strong predictive validity of self-reported E–S cognitive style stands in stark contrast to the small to negligible faculty (and sex) differences for the performance tasks of empathy and systemizing. Against the expectations, no faculty differences were found for the visuospatial tasks, except for a significantly higher performance on a central coherence task by physical science students, which was, however, only small in effect size. Surprisingly the Cartoon Prediction task (a measure of cognitive empathy) was performed more accurately by the physical science students than the social science students, again small in effect size. These small differences between the physical and social science students appeared all independently of sex, i.e. no interactions of faculty by sex were found. One explanation for the difference between self-report and performance measures is that beliefs about cognition and behaviour might be different from objectively assessed cognitive performance and behaviour, because self-reports are more susceptible to social and cultural expectations (Christov-Moore et al. 2014). For example, small to negligible sex differences in cognitive abilities like visuospatial and mathematical aptitude might be magnified by gendered stereotypes and socialization (Halpern 2011; Schmader 2010; Spelke 2005). Several studies have confirmed that individuals may show poorer cognitive abilities in situations that remind them that they are stereotyped to do more poorly, e.g. females perform more poorly than males on a working memory task when the task is framed to identify gender differences in cognitive capacities (Schmader 2010). Our study, however, was not framed towards gender differences (but was framed as a study on different brain types), which may have reduced the influence of gendered stereotype threats. Sex differences in empathy also appear to be more pronounced on explicit measures based on self-report than on implicit performance measures (Christov-Moore et al. 2014). Both the EQ and the SQ have, however, been developed and revised in order to overcome gendered bias. For example, during the development of the EQ, distractor items were added to lead away from the social aspect of the questionnaire, and during the development of the abridged version, items have been excluded that loaded high on social desirability (see Groen et al. 2015). The SQ has also been revised in 2006 by adding more female-specific items in order to deal with the problem of sex-stereotypical responding (Wheelwright et al. 2006). Additionally, there is some evidence for convergent validity of the EQ and SQ with performance measures; people who score low on the EQ also score low on the Eyes test, a

measure for affective empathy (Vellante et al. 2013), while higher SQ scores go along with higher scores on visuospatial tasks, such as mental rotation and ball targeting (Cook and Saucier 2010; Ling et al. 2009). Despite these attempts of overcoming gendered bias, it is still possible that people under- or overestimate their true cognitive abilities because they are socially or culturally biased. As these limitations apply to self-report measures in general, it is advisable to rely not only on self-reports, but also to include more objective measures. Both self-report and performance measures contribute valuable, but distinct types of information about people's cognitive functioning (Fuermaier et al. 2015).

Conclusion

This study provides evidence that self-reported E–S cognitive style better predicts entry into physical or social sciences than sex. However, the skewed distribution of brain types across males (more males with systemizing brain type) and females (more females with empathizing brain type) in the general population (Groen et al. 2015) may explain the internationally observed typical and persistent underrepresentation of females in the STEM fields and underrepresentation of males in the social sciences and health services. Interestingly, students of physical and social sciences did not differ substantially on performance measures of empathy and systemizing. These data support the conclusion that social and physical science students (either male or female) strongly differ in their self-reported cognitive style, but that they do not substantially differ on performance measures of empathy and systemizing. The current study only partially confirms the E–S theory of sex differences, because typical sex differences in this selective sample were only minor and only the self-report measures predicted academic area in the absence of a role for sex. This stresses the importance of using self-reports as well as performance measures for future studies.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

References

- Baron-Cohen S (1999) Can studies of autism teach us about consciousness of the physical and the mental? *Philos Explor* 3:175–188
- Baron-Cohen S (2002) The extreme male brain theory of autism. *Trends Cogn Sci* 6(6):248–254. [https://doi.org/10.1016/S1364-6613\(02\)01904-6](https://doi.org/10.1016/S1364-6613(02)01904-6)
- Baron-Cohen S (2009) Autism: the empathizing–systemizing (E–S) theory. *Year Cogn Neurosci* 1156:68–80. <https://doi.org/10.1111/j.1749-6632.2009.04467.x>
- Baron-Cohen S, Wheelwright S (2004) The empathy quotient: an investigation of adults with asperger syndrome or high functioning autism, and normal sex differences. *J Autism Dev Disord* 34(2):163–175
- Baron-Cohen S, Richler J, Bisarya D, Guranathan N, Wheelwright S (2003) The systemizing quotient: an investigation of adults with asperger syndrome or high-functioning autism, and normal sex differences. *Philos Trans R Soc Lond Ser B Biol Sci* 358(1430):361–374. <https://doi.org/10.1098/rstb.2002.1206>
- Baron-Cohen S, Knickmeyer R, Belmonte M (2005) Sex differences in the brain: implications for explaining autism. *Science* 310(5749):819–823. <https://doi.org/10.1126/science.1115455>
- Billington J, Baron-Cohen S, Wheelwright S (2007) Cognitive style predicts entry into physical sciences and humanities: questionnaire and performance tests of empathy and systemizing. *Learn Individ Differ* 17(3):260–268. <https://doi.org/10.1016/j.lindif.2007.02.004>
- Chen PD, Simpson PA (2015) Does personality matter? Applying holland's typology to analyze students' self-selection into science, technology engineering, and mathematics majors. *J High Educ* 86(5):725–750. <https://doi.org/10.1353/jhe.2015.0024>
- Christov-Moore L, Simpson EA, Coude G, Grigaityte K, Iacoboni M, Ferrari PF (2014) Empathy: gender effects in brain and behavior. *Neurosci Biobehav Rev* 46:604–627. <https://doi.org/10.1016/j.neubiorev.2014.09.001>
- Contreras MJ, Colom R, Shih P, Alava M, Santacreu J (2001) Dynamic spatial performance: sex and educational differences. *Personal Individ Differ* 30(1):117–126. [https://doi.org/10.1016/S0191-8869\(00\)00015-5](https://doi.org/10.1016/S0191-8869(00)00015-5)
- Contreras MJ, Martinez-Molina A, Santacreu J (2012) Do the sex differences play such an important role in explaining performance in spatial tasks? *Personal Individ Differ* 52(6):659–663. <https://doi.org/10.1016/j.paid.2011.12.010>
- Cook CM, Saucier DM (2010) Mental rotation, targeting ability and Baron-Cohen's Empathizing–Systemizing theory of sex differences. *Personal Individ Differ* 49(7):712–716. <https://doi.org/10.1016/j.paid.2010.06.010>
- Correa Varella MA, Benedetti Piccoli Ferreira JH, Pereira KJ, Raad Bussab VS, Valentova JV (2016) Empathizing, systemizing, and career choice in Brazil: sex differences and individual variation among areas of study. *Personal Individ Differ* 97:157–164. <https://doi.org/10.1016/j.paid.2016.03.058>
- Diekmann AB, Brown ER, Johnston AM, Clark EK (2010) Seeking congruity between goals and roles: a new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychol Sci* 21(8):1051–1057. <https://doi.org/10.1177/0956797610377342>
- Ellis L, Ratnasingam M, Wheeler M (2012) Gender, sexual orientation, and occupational interests: evidence of their interrelatedness. *Personal Individ Differ* 53:64–69. <https://doi.org/10.1016/j.paid.2012.02.008>
- Eslinger PJ, Moore P, Troiani V, Antani S, Cross K, Kwok S, Grossman M (2007) Oops! resolving social dilemmas in frontotemporal dementia. *J Neurol Neurosurg Psychiatry* 78(5):457–460. <https://doi.org/10.1136/jnnp.2006.098228>

- Focquaert F, Steven MS, Wolford GL, Colden A, Gazzaniga MS (2007) Empathizing and systemizing cognitive traits in the sciences and humanities. *Personal Individ Differ* 43(3):619–625. <https://doi.org/10.1016/j.paid.2007.01.004>
- Fuermaier ABM, Tucha L, Koerts J, Hauser J, Kaunzinger I, Aschenbrenner S, Weissbrod M, Tucha O (2015) Cognitive impairment in adult ADHD-perspective matters! *Neuropsychology* 29(1):45–58. <https://doi.org/10.1037/neu0000108>
- Geiser C, Lehmann W, Corth M, Eid M (2008a) Quantitative and qualitative change in children's mental rotation performance. *Learn Individ Differ* 18:419–429. <https://doi.org/10.1016/j.lindif.2007.09.001>
- Geiser C, Lehmann W, Eid M (2008b) A note on sex differences in mental rotation in different age groups. *Intelligence* 36:556–563. <https://doi.org/10.1016/j.intell.2007.12.003>
- Groen Y, Fuermaier ABM, Den Heijer AE, Tucha O, Althaus M (2015) The empathy and systemizing quotient: the psychometric properties of the Dutch version and a review of the cross-cultural stability. *J Autism Dev Disord* 45:2848–2864. <https://doi.org/10.1007/s10803-015-2448-z>
- Halpern DF (2011) Sex differences in cognitive abilities, 4th edn. Psychology Press, New York and Hove
- Horn W (1983) *Leistungsprüfsystem L-P-S*, 2nd edn. Hogrefe Verlag, Göttingen
- Kimura D (2002) Men and women display patterns of behavioral and cognitive differences that reflect varying hormonal influences on brain development. *Sci Am* 12:32–37
- Kret ME, De Gelder B (2012) A review on sex differences in processing emotional signals. *Neuropsychologia* 50(7):1211–1221. <https://doi.org/10.1016/j.neuropsychologia.2011.12.022>
- Ling J, Burton TC, Salt JL, Muncer SJ (2009) Psychometric analysis of the systemizing quotient (SQ) scale. *Br J Psychol* 100:539–552. <https://doi.org/10.1348/000712608X368261>
- Lippa RA (2006) The gender reality hypothesis. *Am Psychol* 61(6):639–640. <https://doi.org/10.1037/0003-066X.61.6.639>
- Malgwi CA, Howe MA, Burnaby PA (2005) Influences on students' choice of college major. *J Educ Bus* 80(5):275–282. <https://doi.org/10.3200/JOEB.80.5.275-282>
- Manson C, Winterbottom M (2012) Examining the association between empathising, systemising, degree subject and gender. *Educ Stud* 38(1):73–88. <https://doi.org/10.1080/03055698.2011.567032>
- Ministry of Education, Culture and Sport (2015) Panorama de la educación; Indicadores de la OCDE. <http://www.mecd.gob.es/dctm/inee/internacional/panorama-de-la-educacion-2015.-informe-espanol.pdf?documentId=0901e72b81ee9fa3>. Accessed 25 Sept 2017
- Montagne B, Kessels RPC, Frigerio E et al (2005) Sex differences in the perception of affective facial expressions: do men really lack emotional sensitivity? *Cogn Process* 6:136. <https://doi.org/10.1007/s10339-005-0050-6>
- Montreuil T, Bodnar M, Bertrand M, Malla AK, Joober R, Lepage M (2010) Social cognitive markers of short-term clinical outcome in first-episode psychosis. *Clin Schizophr Relat Psychos* 4(2):105–114. <https://doi.org/10.3371/CSRP.4.2.2>
- National Science Foundation (2013) Women, minorities, and persons with disabilities in science and engineering. http://www.nsf.gov/statistics/wmpd/2013/pdf/nsf13304_digest.pdf. Accessed 25 Sept 2017
- Nazareth A, Herrera A, Pruden SM (2013) Explaining sex differences in mental rotation: role of spatial activity experience. *Cogn Process* 14:201. <https://doi.org/10.1007/s10339-013-0542-8>
- O'Sullivan M, Guilford JP (1976) In: Sheridan Psychological Services (ed) Four factor tests of social intelligence (behavioural cognition). Manual of instructions and interpretations. Consulting Psychologists Press, Palo Alto
- Platform Beta techniek (2014) Facts and figures 2014. [http://www.platformbetatechniek.nl/media/files/publicaties/FF2014-DEF\(1\).pdf](http://www.platformbetatechniek.nl/media/files/publicaties/FF2014-DEF(1).pdf). Accessed 17 June 2015
- Prediger DJ (1982) Dimensions underlying Holland's hexagon: missing link between interests and occupations? *J Vocat Behav* 21:259–287. [https://doi.org/10.1016/0001-8791\(82\)90036-7](https://doi.org/10.1016/0001-8791(82)90036-7)
- Rodán A, Contreras MJ, Elosua MR, Gimeno P (2016) Experimental but not sex differences of a mental rotation training program on adolescents. *Front Psychol* 7:1050. <https://doi.org/10.3389/fpsyg.2016.01050>
- Sasson NJ, Pinkham AE, Richard J, Hughett P, Gur RE, Gur RC (2010) Controlling for response biases clarifies sex and age differences in facial affect recognition. *J Nonverbal Behav* 34:207–221. <https://doi.org/10.1007/s10919-010-0092-z>
- Schmader T (2010) Stereotype threat deconstructed. *Curr Dir Psychol Sci* 19(1):14–18. <https://doi.org/10.1177/0963721409359292>
- Spelke, ES (2005) Sex Differences in Intrinsic Aptitude for Mathematics and Science? A critical review. *Am Psychol* 60(9):950–958. <https://doi.org/10.1037/0003-066X.60.9.950>
- Su R, Rounds J (2015) All STEM fields are not created equal: people and things interests explain gender disparities across STEM fields. *Front Psychol* 6:1–20. <https://doi.org/10.3389/fpsyg.2015.00189>
- Su R, Rounds J, Armstrong PI (2009) Men and things, women and people: a meta-analysis of sex differences in interests. *Psychol Bull* 135:859–884. <https://doi.org/10.1037/a0017364>
- Vellante M, Baron-Cohen S, Melis M, Marrone M, Petretto DR, Masala C, Preti A (2013) The “reading the mind in the eyes” test: systematic review of psychometric properties and a validation study in Italy. *Cogn Neuropsychiatry* 18(4):326–354. <https://doi.org/10.1080/13546805.2012.721728>
- Voyer D, Voyer S, Bryden M (1995) Magnitude of sex-differences in spatial abilities—a meta analysis and consideration of critical variables. *Psychol Bull* 117(2):250–270. <https://doi.org/10.1037/0033-2909.117.2.250>
- Wheelwright S, Baron Cohen S, Goldenfeld N, Delaney J, Fine D, Smith R (2006) Predicting autism spectrum quotient (AQ) from the systemizing quotient-revised (SQ-R) and empathy quotient (EQ). *Brain Res* 1:47–56
- Woodcock A, Graziano W G, Branch SE, Habashi MM, Ngambeki I, Evangelou D (2013) Person and thing orientations: psychological correlates and predictive utility. *Soc Psychol Personal Sci* 4:116–123. <https://doi.org/10.1177/1948550612444320>