Equality, Diversity and Inclusion: An International Journ...

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Received 20 November 2013
Revised 17 March 2014
15 June 2014
27 June 2014
3 July 2014
Accepted 4 July 2014

Trapped in the gender stereotype? The image of science among secondary school students and teachers

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Abstract

Purpose – The purpose of this paper is to investigate the gender stereotype of science by analysing the semantic attributes of gender in relation to three science subjects – chemistry, mathematics, and physics – among students and their science teachers.

Design/methodology/approach – This cross-sectional study applied a survey of 3,045 students and 123 teachers in secondary schools. The gendered image of science was assessed using a semantic differential consisting of 25 pairs of adjectives with semantically opposite meanings.

Findings – In summary, the results of the study demonstrate that from the female students' perspective mathematics and physics are negatively related to female gender, whereas chemistry is neither significantly related to the male nor to the female profile. From the male students' point of view mathematics is negatively related to the female gender, whereas chemistry and physics are positively related to the male gender. In the science teachers' perception chemistry and physics combine feminine and masculine attributes, whereas the teachers' perception of mathematics matches only with the male, but not with the female gender.

Originality/value – In contrast to previous research, the study is the first to analyse the gender stereotype of chemistry as well as to assess the gender image of three science subjects from students' and teachers' perspectives.

Keywords Gender, Sciences, Teaching, Students, Education, Mathematics

Paper type Research paper

Introduction

The gender gap with male dominance in the fields of science, technology, engineering, and mathematics (STEM) remains persistent "at almost all levels of education and career stages" (Lane *et al.*, 2012, p. 221) and has been well documented across most OECD countries (OECD, 2006, 2009, 2013). Although the gender gap has narrowed in terms of the proportion of female participation in higher education, the choice of study domain remains highly gender-dependent; in particular, the engineering and computing sciences are avoided by female and preferred by male students (OECD, 2006). Moreover, even those women who receive STEM degrees are less likely to choose STEM careers compared to males with STEM degrees (Beede *et al.*, 2011).

The question of why gender inequalities are reproduced in career choice was implicitly addressed by Gottfredson (2002, 2005). According to her theoretical

Equality, Diversity and Inclusion: An International Journal
Vol. 34 No. 2, 2015
pp. 106-123

2040-7149
DOI 10.1108/EDI-11-2013-0097

The authors gratefully acknowledge the Swiss National Science Foundation for financial support of the study "Gender atypical careers of young women".

framework, occupational aspirations are incorporated in the individual self-image, which is developed through the process of circumscription and compromise from early childhood through adolescence. "Forming occupational aspirations is a process of comparing one's self-image with images of occupations and judging degree of match between the two" (Gottfredson, 2002, p. 93). In this process the sex type of an occupation is especially crucial for career choice because the "wrong" sex type of an occupation is more fundamental for self-concept than the prestige of an occupation or individual interests. The judgement as to whether an occupational sex type is right or wrong for oneself is embedded in different social expectations associated with the socio-culturally established gender roles which children and youth acquire in various socialization contexts. Applying Gottfredson's theory, the decisive impact of the "matching sex type" of an occupation in the process of career choice was confirmed in a number of studies (Bubany and Hansen, 2011; Howard *et al.*, 2011; Ratschinski, 2009).

Thus, the present study is aimed at analysing the gender image of mathematics and science within the educational context in order to contribute to knowledge that can improve gender equality in STEM occupations.

Assessment of the gender stereotype of math and science

Attitudes towards science and the perception of science and scientists have been assessed through a variety of methods. Some studies applied a Draw-A-Scientist Test (DAST), which is based on the visualization of children's and youths' images of science and scientists, using their drawings of a scientist or of a scientific workplace (e.g. Chambers, 1983; Finson, 2002; Scherz and Oren, 2006). A large body of studies on the gender stereotype of math originated in the theoretical framework of implicit social cognition (Greenwald and Banaji, 1995; Greenwald *et al.*, 2002). These studies applied an Implicit Association Test (IAT), which is a computer-based assessment of the math-gender stereotype through strength of association between math and male vs math and female compared to gender associations with other terms (e.g. language, liberal art) (e.g. Greenwald *et al.*, 1998; Nosek *et al.*, 2002). Other studies applied an explicit stereotype assessment of the gender stereotype of math and science – in some studies combined with an implicit assessment – using self-report measures of participants' preferences and attitudes (e.g. Nosek *et al.*, 2002; Kessels, 2005). A number of studies applied a semantic differential, which is also an explicit technique of gender stereotype assessment. This technique measures respondents' connotative association with a concept or stimulus on a bipolar scale with contrasting adjectives at each end (e.g. hard – soft) (e.g. Herzog *et al.*, 1998). Finally, research on the gender stereotype of science has also applied qualitative methods, such as individual or group interviews (e.g. Archer *et al.*, 2010).

The gender image of a scientist

Taasoobshirazi and Carr (2008) evaluated the perception of the scientist among students using the DAST. The studies reviewed were consonant with the stereotypical image of a scientist as being a primarily male person. The exact image of scientists held by middle school students was reported by Scherz and Oren (2006, p. 977) who, using a DAST assessment, found that "the common image was that of a scientist as a bespectacled male with unkempt hair in a white lab-coat". In addition, Finson (2002) reported that in drawings by students enroled in teacher training the same stereotypical image of a scientist was most prevalent.

Studies on the gender image of science subjects based on self-report measures assessing students' representations of science and scientists showed that although elementary school boys and girls are all attracted by the "flamboyant and explosive nature of science", fewer girls than boys can imagine a future career in science (Archer *et al.*, 2010, p. 6). Thus, the study suggests that although young children do not have widespread knowledge about a future career in science, they implicitly learn from an early age that science has masculine traits. From the boys' point of view, science is masculine due to the fact that it is "natural" for girls not to be interested in science because "fashion and science don't mix" and because "the scientists they know are all men" (Archer *et al.*, 2010, p. 19). Another study among eighth and ninth grade high school students has shown that the prototypical student disapproving of physics and math has a more positive image among peers and is described as "more physically and socially attractive, as less isolated and better integrated, as more creative and more emotional" compared to the prototypical student favouring science (Hannover and Kessels, 2004, p. 62). However, there were only slight differences between the self-image of girls and boys. Girls attributed more social competence to their self-image, more creativity and more emotionality compared to the boys' self-image, but on the other dimensions, girls' and boys' self-views did not differ (Hannover and Kessels, 2004, p. 62). Another study showed that prototypical students preferring physics were perceived as more masculine and less feminine. Moreover, boys disliked girls who liked physics, and girls who excelled in physics reported feeling unpopular with boys (Kessels, 2005).

The gender image of mathematics

A European study by Steffens *et al.* (2010) reported that implicit math-gender stereotyping was already observed among girls at the age of nine years. The math-gender stereotype among adolescent girls was more pronounced than among adolescent boys, who, on average, were less likely to exhibit implicit gender-stereotypic associations. Moreover, a study among college students showed that even young women who had chosen math-intensive majors in their undergraduate studies had difficulties associating math with the self because of the wrong "sex type" as they associated the self with female and math with male gender (Nosek *et al.*, 2002).

By combining implicit and explicit measures of mathematics and the mathematician stereotype, some studies have shown that the stereotypic image of science and the scientist is already pronounced among young children. Accordingly, in the perception of elementary school girls, men were rated as liking math better than women and as outperforming women in this discipline. Additionally, girls also associated the concept of adult mathematician more with men than with women (Steele, 2003). Similar findings on a math-gender stereotype were reported by Cvencek *et al.* (2011), who found existence of the implicit as well as explicit gender stereotype of math already among second grade children. Thus, already at this age children shared the attitude that math is for boys and not for girls, and the boys' identification with math was stronger than that of girls.

The gender image of science

A study across 34 countries applying the IAT revealed an implicit gender-science-stereotype based on the association of science with male rather than with female gender among respondents whose average age was 27 years (Nosek *et al.*, 2009).

In order to analyse the gendered image of physics among students and their teachers in secondary schools in Switzerland, Herzog *et al.* (1998) applied the semantic differential suggested by Hofstätter (1973). The results of the study indicated that the term physics correlated significantly positively with the term man among students (among girls: $r = 0.59$, $p < 0.01$ and among boys $r = 0.71$, $p < 0.01$) as well as among teachers ($r = 0.65$, $p < 0.01$) (Herzog *et al.*, 1998, p. 54). At the same time the term physics correlated negatively with the term woman; however, this correlation was not significant, either among students or among teachers (Herzog *et al.*, 1998, p. 54).

Similar findings with respect to the gender image of science highlighted that 11th grade students associate physics more readily (relative to English as a school subject) with words referring to males rather than to females (Kessels *et al.*, 2006). With respect to the identity development of female students Kessels *et al.* (2006, p. 775) conclude that: "Being interested in physics would endanger their newly acquired identity as a woman-to-be because the masculine image of physics denies girls who like the subject femininity and popularity with boys". In line with these findings Breakwell *et al.* (2003) reported that among students aged 11-15 years imaginary girls who liked science were perceived as being less feminine. Interestingly, however, the same study found that the imaginary boy who liked science was perceived as being more feminine. Based on these findings Breakwell *et al.* (2003, p. 452) concluded that the link between liking science and gender stereotype "is far from simple and is not captured by phrases such as 'science is de-feminizing' or 'science is masculine'".

Focus of the study

Overall, previous research on the image of science among students provides solid empirical evidence of a gender bias. However, beyond the fact that science is associated with male rather than with female gender among students of both genders, little is known about semantic attributes associated with science and gender. To extend knowledge on the gender image of science subjects at school, the first objective of our study was, therefore, to determine which attributes are associated with the two genders and how these attributes are related to science.

Furthermore, the studies discussed above analysed the gender stereotype of mathematics and/or physics, but failed to provide evidence on the gender image of chemistry and the semantic attributes associated with it. To overcome this research gap, the second objective of our study was to analyse the gender image of three science subjects, namely chemistry, mathematics and physics, at secondary schools.

Finally, as revealed by the review of research on gender stereotypes towards science, previous studies predominantly focused on the image of science among students, but empirical evidence with respect to the image of science among science teachers is largely lacking. Thus, the third objective of our study was to explore gender stereotyping towards science among both secondary school students and their science teachers.

Method

Participants

Secondary school students from 168 classes in the German-speaking part of Switzerland, and their science teachers were surveyed between January and April 2011 (Makarova *et al.*, 2012). Overall, 3,045 students (55.8 per cent female and 44.2 per cent male, average age 18.8 years, $SD = 1.34$) participated in this study. The student sample was representative for secondary schools in Switzerland.

The teacher sample comprised 123 teachers (17.4 per cent female and 82.6 per cent male, average age 46.0 years, $SD = 10.30$). Of the teachers, 40 (32.5 per cent) taught chemistry, 40 (32.5 per cent) taught mathematics and 43 (35.0 per cent) taught physics. The over-representation of male science teachers in our sample corresponds to the higher proportion of male teachers in secondary schools in Switzerland (Swiss Federal Statistical Office (SFSO), 2013) and reflects the fact that science subjects in secondary schools are taught predominantly by men.

Measurements

For the purpose of this study an explicit measurement of attitudes was chosen over an implicit measurement of attitudes, because the study does not focus on "hidden attitudes" but is interested in salient attitudes towards gender and science among students and teachers (Millon *et al.*, 2003, p. 356). One of the most popular techniques of explicit attitude assessments is the semantic differential technique (Millon *et al.*, 2003). "The Semantic Differential (SD) measures people's reactions to stimulus words and concepts in terms of ratings on bipolar scales defined with contrasting adjectives at each end […]" (Heise, 1970, p. 235). The semantic differential scale was originally developed by Osgood, who recommended the use of the seven-point bipolar scale to assess "the meaning variable in human behaviour" (Osgood *et al.*, 1957, p. 76). This is a highly generalizable measurement technique, which must be adapted to a particular research goal (Osgood *et al.*, 1957). Consequently, the methodological advantage of the semantic differential scale is that it allows assessing respondents' connotative association "to any concept or stimulus" (Heise, 1970, p. 236). The basic assumption of the semantic differential is embedded in congruity theory. It assumes that "when two concepts are associated the attitudes towards the concepts tend to converge, and when two concepts are dissociated (contrasted), the attitudes tend to diverge" (Heise, 1970, p. 249).

In our study this technique allows analysis of whether the attributes of the analysed constructs – female, male, and science – converge or contrast in the perception of students and their teachers. Thus, attitudes towards gender and science were measured using the original method by Osgood *et al.* (1957), which Hofstätter (1973) adapted to the context of German-speaking countries. The instrument was validated in a study of the gender stereotype of school subjects – physics and French – among students and teachers of secondary schools in Switzerland (Herzog *et al.*, 1998) and was therefore chosen for the purpose of our study. The semantic differential consisted of 25 pairs of adjectives with semantically opposite meaning (e.g. hard – soft) to assess the connotations of the terms woman, man, chemistry, mathematics, and physics.

The students and teachers were instructed as follows: "Below you will find 25 pairs of contrasting adjectives for the term 'chemistry'. Most of these adjectives are (metaphorically) related to the term 'chemistry'. Please indicate for each pair of adjectives which properties in your opinion best go with the term 'chemistry'. Do not think for too long, but make your judgments spontaneously". The instructions were adapted for each semantic deferential by replacing the target term (i.e. woman, man, chemistry, mathematics, physics). The students' and teachers' associations with these terms were assessed on a seven-point scale (1 = greatly, 2 = fairly, 3 = somewhat, 4 = neither, 5 = somewhat, 6 = fairly, 7 = greatly).

The student sample was divided into six groups, with each group completing the semantic differential for one science and one gender term: chemistry and woman ($N = 484$), chemistry and man ($N = 488$), mathematics and woman ($N = 389$), mathematics and man ($N = 607$), physics and woman ($N = 536$), and physics and man ($N = 541$).

Teachers completed the semantic differential for the science subject they taught (chemistry $N = 35$, mathematics $N = 37$, and physics $N = 40$) and both gender terms (woman $N = 114$ and man $N = 113$).

Data analysis

According to Heise (1970), the most common method for analysing semantic differential is to calculate an average score in a certain group rather than averaging individual scores. The mean value of the group is a generalization of the semantic connotation of the particular construct in that particular group, which allows comparing the semantic profiles of assessed terms across groups, but not across individuals. The degree to which two constructs are congruent or incongruent with each other within one group can be calculated using correlative analysis (Hofstätter, 1973).

Thus, in the first step, the mean values were calculated for each adjective pair on the semantic differential separately for each group analysed (i.e. female students, male students, and teachers). In the second step, the Pearson correlations of the assessed semantic profiles (woman, man, chemistry, mathematics, and physics) were calculated using the mean value of each adjective pair within the group mean. In the third step, the connotative attributes of the assessed terms were analysed using the semantic meaning of the adjective pairs with mean values of either $\leqslant 3.50$ or $\geqslant 4.50$ on the seven-point semantic differential scale. The attributes of the adjective pairs with mean values between 3.50 and 4.50 were excluded from analysis because no clear semantic meaning can be attributed to adjectives with mean values in the scale range "neither" (see Tables II, IV, and VI).

Results

The image of science among female students

Table I shows that, for female students, the semantic profiles of the three science subjects correlate significantly positively. In contrast, the semantic profiles of the terms man and woman do not correlate significantly.

With regard to the gendered connotations of science, our results indicate that in the perception of female students there are no significant correlations between the semantic profile of the term man and any of the science subjects. In contrast, the semantic profile of the term woman correlates significantly negatively with the semantic profiles of the terms mathematics and physics. However, the term woman has no significant correlation with the term chemistry.

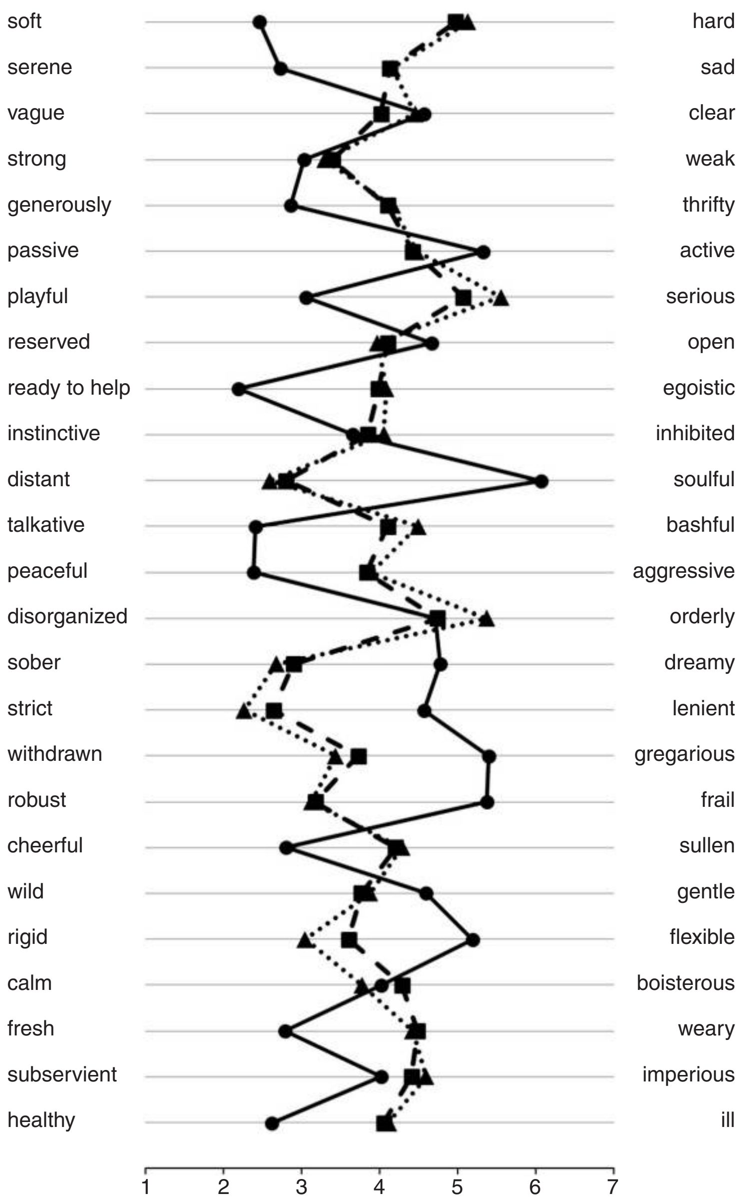
Figure 1 illustrates that the terms mathematics and physics have a similar semantic profile in the perception of female students. However, the semantic profile of the term woman and the semantic profiles of the two science subjects diverge greatly.

The term woman was associated by female students with attributes such as soft, strong, playful, soulful, orderly, dreamy, lenient, gregarious, frail, and flexible (cf. Table II for mean values). Only two of these adjectives – strong and orderly – are also attributed to the semantic profiles of mathematics and physics. Conversely, most of the attributes which female students associated with science are semantically opposed to those which

Table I. Pearson correlations of the terms woman, man, chemistry, mathematics, and physics: perspective of female students

	Man	Chemistry	Mathematics	Physics
Woman	0.38	−0.37	−0.47*	−0.46*
Man		0.35	0.12	0.26
Chemistry			0.93***	0.98***
Mathematics				0.96***

Notes: $*p < 0.05$; $***p < 0.001$



Notes: Symbols: ●, Woman; ▲, Mathematics; ■, Physics. Lines connect means of the same term. Scale: 1=greatly, 2=fairly, 3=somewhat, 4=neither, 5=somewhat, 6=fairly, 7=greatly

Figure 1.
Semantic profiles of the terms woman, mathematics, and physics: perspective of female students

they associated with the term woman. Thus, the two science terms are perceived by young women as hard, serious, distant, sober, strict, and robust. Additionally, the term mathematics is connoted with the attributes withdrawn and rigid; the term woman, on the other hand, is associated with their opposites.

	Woman $N = 728$	Mathematics $N = 502$	Physics $N = 548$
Soft-hard	2.45	5.13	4.97
Strong-weak	3.03	3.29	3.39
Playful-serious	3.05	5.55	5.07
Distant-soulful	6.06	2.59	2.80
Disorganized-orderly	4.71	5.37	4.74
Sober-dreamy	4.77	2.67	2.89
Strict-lenient	4.57	2.26	2.63
Withdrawn-gregarious	5.40	3.43	3.72
Robust-frail	5.37	3.12	3.17
Rigid-flexible	5.19	3.04	3.60

Notes: Only means of the science subject terms which correlate significantly either with the term woman or with the term man are displayed. Scale: 1 = greatly, 2 = fairly, 3 = somewhat, 4 = neither, 5 = somewhat, 6 = fairly, 7 = greatly

Table II. Means of the terms woman, mathematics, and physics: perspective of female students

The image of science among male students

In the perception of male students, the semantic profiles of the three science subjects correlate significantly positively. In contrast, the semantic profiles of the terms man and woman do not correlate significantly (see Table III).

With respect to the gendered connotations of science, male students perceive a significantly negative correlation between the semantic profiles of the terms mathematics and woman. Figure 2 demonstrates that the semantic profile of the term woman diverges from that of the term mathematics.

However, the term woman has no significant correlation with the semantic profiles of terms chemistry and physics. In contrast, the terms chemistry and physics correlate significantly positively with the semantic profile of the term man.

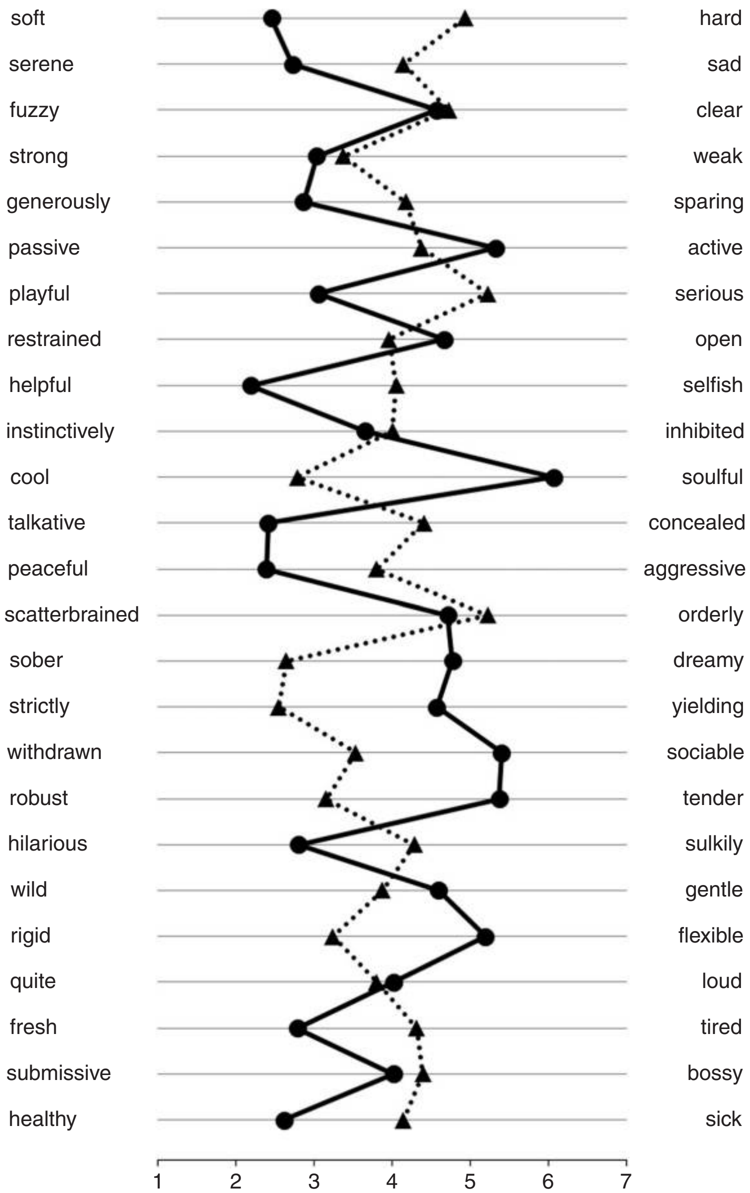
The term woman was associated by male students with attributes such as soft, playful, soulful, dreamy, lenient, frail, and flexible (for mean values cf. Table IV). Conversely, young men perceive the term mathematics with opposite attributes, such as hard, serious, distant, sober, strict, robust, and rigid. However, their semantic profiles for the term man on the one hand and the terms chemistry and physics on the other show considerable overlap (cf. Figure 3).

As shown in Table IV, the term man is associated by male students with attributes such as hard, clear, active, strict, and robust. The terms chemistry and physics were also associated with attributes such as active, strict, and robust. Beyond these, in the perception of young men, the term physics had two more overlapping attributes with the term man, i.e. hard and clear.

	Man	Chemistry	Mathematics	Physics
Woman	−0.02	−0.17	−0.60**	−0.29
Man		0.70***	0.34	0.64**
Chemistry			0.77***	0.94***
Mathematics				0.88***

Notes: $^{**}p < 0.01$; $^{***}p < 0.001$

Table III. Pearson correlations of the terms woman, man, chemistry, mathematics, and physics: perspective of male students



Notes: ●, Woman, ▲, Mathematics. Lines connect means of the same term. Scale: 1=greatly, 2=fairly, 3=somewhat, 4=neither, 5=somewhat, 6=fairly, 7=greatly

Figure 2.
Semantic profiles of the terms woman and mathematics: perspective of male students

The image of science among teachers

From the teachers' point of view (see Table V), the semantic profiles of the three science subjects correlate significantly positively. In contrast, the semantic profiles of the terms man and woman do not correlate significantly.

With respect to the gendered connotations of science there are no negative correlations either with the term man or with the term woman. Thus, teachers perceive a significant positive correlation between the connotations of the term man and the connotations of all science subjects (chemistry, mathematics, and physics). The term woman, on the other hand, correlates significantly positively only with the semantic profiles of the terms chemistry and physics, but has no significant correlation with the term mathematics (see Table V).

As shown in Table VI, the term woman on the one hand and the terms chemistry and physics on the other share attributes in the teachers' perception; these shared attributes include serene, strong, active, open, ready to help, gregarious, cheerful, flexible, fresh, and healthy. However, there are also four attributes (soft, dreamy, lenient, and frail) which were ascribed only to the term woman; their opposites (hard, sober, strict, and robust) were ascribed to both science terms.

In addition, Table VI shows that in the teachers' perception, the term man on the one hand and the terms chemistry, mathematics, and physics on the other share attributes such as: hard, serene, clear, strong, active, sober, robust, and healthy. Beyond this, the term chemistry has two more overlapping attributes with the term man (instinctive and boisterous).

Discussion

The present study aimed to refine knowledge about the gender stereotypes of science by analysing the semantic attributes of gender and science subjects among students and their science teachers.

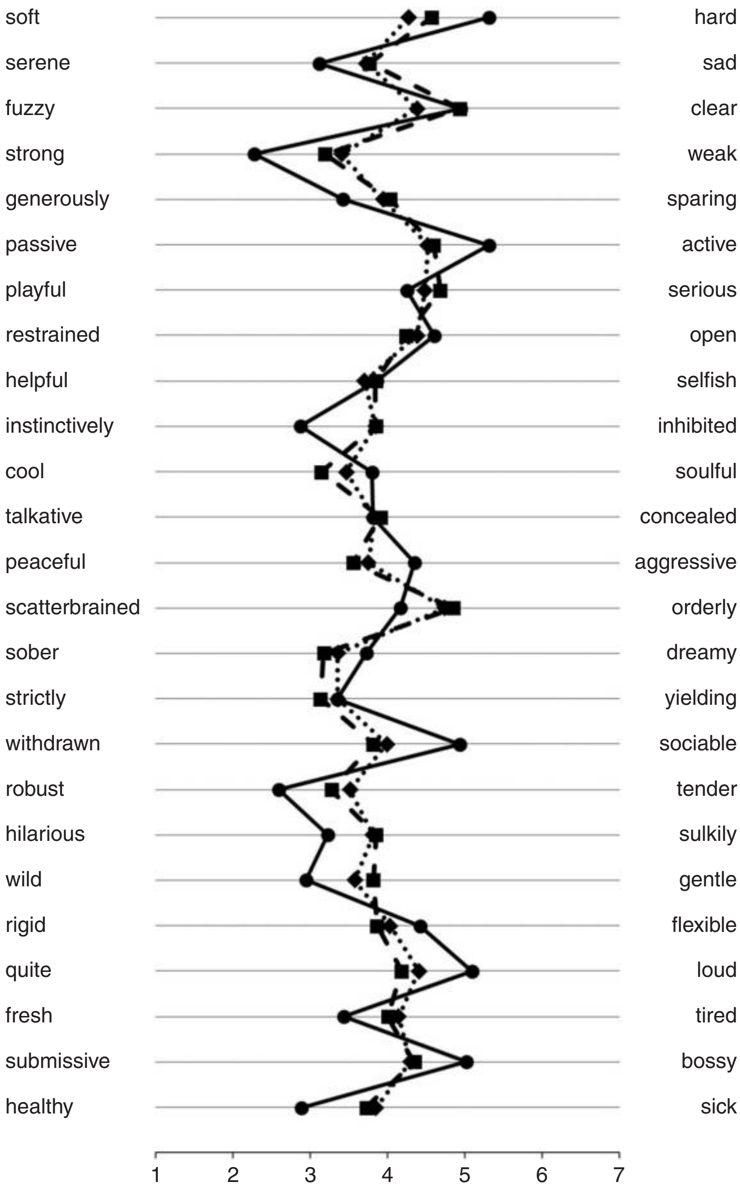
The positive significant correlation between the semantic profiles of the science subjects analysed showed that chemistry, physics, and mathematics are highly related to each other in the perception of students and their science teachers. However, with respect to the semantic image of chemistry, physics, and mathematics in secondary schools our study demonstrates that gender stereotypes do not affect all science subjects equally.

The analyses of the students' associations between science and gender demonstrated that the semantic profile of mathematics correlates significantly negatively with the

	Woman $N=538$	Man $N=660$	Chemistry $N=367$	Mathematics $N=413$	Physics $N=446$
Soft-hard	2.32	5.31	4.27	4.93	4.56
Vague-clear	4.01	4.94	4.38	4.72	4.93
Passive-active	4.62	5.31	4.52	4.37	4.59
Playful-serious	3.07	4.25	4.48	5.22	4.68
Distant-soulful	5.83	3.79	3.46	2.78	3.14
Sober-dreamy	4.53	3.72	3.35	2.64	3.17
Strict-lenient	4.63	3.34	3.35	2.54	3.13
Robust-frail	5.71	2.59	3.50	3.15	3.27
Rigid-flexible	5.16	4.42	4.03	3.24	3.86

Notes: Scale: 1 = greatly, 2 = fairly, 3 = somewhat, 4 = neither, 5 = somewhat, 6 = fairly, 7 = greatly

Table IV. Means of the terms woman, man, chemistry, mathematics, and physics: perspective of male students



Notes: ●, Man, ♦, Chemistry, ■, Physics. Lines connect means of the same term. Scale: 1=greatly, 2=fairly, 3=somewhat, 4=neither, 5=somewhat, 6=fairly, 7=greatly

Figure 3.
Semantic profiles of the terms man, chemistry, and physics: perspective of male students

semantic profile of the female gender. The negative correlation of mathematics and women was found among female as well as among male students. These results confirm findings of previous studies on an implicit math stereotype, namely that mathematics and women do not go together (Cvencek *et al.*, 2011; Nosek *et al.*, 2002, 2009; Steele, 2003;

Steffens *et al.*, 2010). With respect to physics our study shows that from the female students' perspective physics is characterized by traits which are opposite to the female gender. At the same time, from the male students' perspective, physics matches attributes of the male gender. Comparing the gender stereotype of physics among students surveyed by Herzog *et al.* (1998) with that among students from our study, we found that among male students the positive correlation of physics with male gender remained unchanged. What is interesting, however, is that in the perception of contemporary young women physics is no longer positively related to the male gender but has shifted to a negative relation with the female gender. Thus, our results not only support previous findings with respect to the masculine image of physics (Kessels, 2005; Kessels *et al.*, 2006) but at the same time suggest that for contemporary young women both expressions are true: mathematics ≠ women and physics ≠ women. Accordingly, in the students' perception of the two genders the image of mathematics and physics are predominantly characterized by masculine traits such as hard, serious, distant, sober, strict, rigid, and robust. These attributes are opposite to the students' perception of feminine traits, which are soft, playful, soulful, dreamy, lenient, flexible, and frail. Taking into account that already in the 1970s the term man – in contrast to the term woman – was associated with the same semantic attributes (Hofstätter, 1973, p. 258),

Table V. Pearson correlations of the terms woman, man, chemistry, mathematics, and physics: perspective of teachers

	Man	Chemistry	Mathematics	Physics
Woman	0.04	0.43*	0.29	0.42*
Man		0.71***	0.58**	0.64**
Chemistry			0.84***	0.93***
Mathematics				0.90***

Notes: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table VI. Means of the terms woman, man, chemistry, mathematics, and physics: perspective of teachers

	Woman $N = 114$	Man $N = 113$	Chemistry $N = 35$	Mathematics $N = 37$	Physics $N = 40$
Soft-hard	2.88	4.75	4.76	5.03	4.95
Serene-sad	3.25	3.47	2.71	2.95	2.77
Vague-clear	4.10	4.73	5.71	6.62	6.02
Strong-weak	3.49	3.07	2.55	2.41	2.36
Passive-active	4.58	4.86	5.89	5.49	5.72
Reserved-open	4.53	4.41	5.21	4.72	5.42
Ready to help-egoistic	2.76	3.83	3.38	3.68	3.37
Instinctive-inhibited	3.97	3.40	3.42	3.64	3.67
Sober-dreamy	4.50	3.38	2.92	2.82	2.72
Strict-lenient	4.49	3.47	2.82	2.56	2.65
Withdrawn-gregarious	4.93	4.29	4.55	3.84	4.49
Robust-frail	4.60	3.04	3.47	3.03	2.84
Cheerful-sullen	3.21	3.55	2.82	2.97	3.12
Rigid-flexible	4.76	4.23	5.34	5.34	4.93
Calm-boisterous	4.00	4.65	4.53	3.68	4.05
Fresh-weary	3.30	3.59	2.82	3.21	3.05
Healthy-ill	3.17	3.32	3.05	2.92	2.81

Notes: Scale: 1 = greatly, 2 = fairly, 3 = somewhat, 4 = neither, 5 = somewhat, 6 = fairly, 7 = greatly our study gives strong support to the idea that gender stereotypes still persist and that in the students' perception mathematics and physics are trapped in the masculine gender stereotype. Thus, by illustrating that attributes of mathematics and physics are negatively related to the feminine profile, our findings provide strong support for the suggestion that young women can hardly associate either mathematics or physics with their self (Nosek *et al.*, 2002; Kessels *et al.*, 2006). Consequently, the masculine image of science is also transferred to the image of the science teacher. Thus, most Dutch and German secondary school students "had thought of a man when describing the typical physics teacher. Similarly, in Germany the typical mathematics teacher was imagined as a man by the majority of the students" (Kessels and Taconis, 2012, p. 1065). These findings match the current demographics of teachers in the secondary schools of Switzerland, where physics and mathematics are predominantly taught by male teachers.

Following Kessels and Taconis (2012, p. 1067), students' choice of mathematics or physics as a major subject was likely when students found the typical teacher of the respective subjects to be more similar to themselves. In line with this Lane *et al.* (2012, p. 229) reported that "robust associations between male and science […] completely accounted for the gap in men and women's academic plans". Thus, our results suggest that the masculine profile of physics and mathematics negatively affects young women's choice of hard science subjects as their field of interest and expertise.

In this context our findings with regard to chemistry would appear to be important. Although in the male students' perception chemistry is significantly positively correlated with the male profile, it has far fewer attributes that overlap with the masculine semantic profile compared to mathematics and physics. Thus, only three traits – active, strict, and robust – match both terms chemistry and man in the male students' perception. Moreover, from the female students' point of view chemistry is neither significantly related to the male nor to the female profile. We therefore suggest that young women can more easily identify self with chemistry because of its diffuse gender profile. In addition, this finding confirms the suggestion that the link between images of science and gender is more complex than just being masculine as opposed to being feminine (Breakwell *et al.*, 2003).

In the light of research on gender differences in students' interest in science our study suggests that the nature of the gender stereotype is related to the nature of students' interest in science (Murphy and Whitelegg, 2006, p. 3f). Accordingly, a positive relation of physics and male gender from the male students' perspective is related to boys' stronger interest in physics compared to that of girls, who perceive a negative relation of physics with female gender. At the same time the lack of a manifest gender stereotype of chemistry from the female students' perspective can be related to the finding that girls favour chemistry more than physics, which is perceived as being counter to their gender. In line with this a cross-national study on implicit gender-science-stereotype and gender gap in science and math achievement suggested that "gender stereotypes and sex gaps in scientific engagement are mutually reinforcing" (Nosek *et al.*, 2009, p. 10596). This notion is supported by undergraduate enrolment in chemistry and physics at Swiss universities for the academic year 2013-2014, where 33.6 per cent of all students majoring in chemistry were female compared to only 18.0 per cent majoring in physics (Swiss Federal Statistical Office (SFSO), 2014). In addition, we assume that the negative correlation of mathematics and physics with the feminine profile among female students endangers their academic success because, as shown by previous research, students who have a strong identification with an academic domain "choose to engage in academic activities, put forth more effort to succeed academically, and persist longer in the face of frustration or failure than those who have disidentified because their self-esteem would be more strongly influenced by academic performance" (Osborne and Jones, 2011, p. 139).

However, there is sufficient empirical evidence on the positive influence of gender-inclusive math and science education on girls' interest and achievement in science subjects at school (Budde, 2009; Häussler and Hoffmann, 1995; Halpern *et al.*, 2007; Herzog, 1998; Herzog *et al.*, 1997, 1999; Kahle *et al.*, 1993; Labudde *et al.*, 2000). Accordingly, in order to encourage and promote girls' interest in math and science, one of the evidence-based recommendations to teachers is to choose educational activities which "do not reinforce existing gender stereotypes" (Halpern *et al.*, 2007, p. 7). It is, therefore, important that teachers are encouraged to be aware of their own gender beliefs and stereotypes and their influence on their teaching practice (Li, 2004; Bieri Buschor *et al.*, 2014). Thus, the question of whether the gender stereotype of science is pronounced among science teachers is immanent for the discussion of gender equity in math and science education.

Based on our study, science teachers in Swiss secondary schools associate chemistry and physics with both genders, although the correlation of chemistry and physics with the male gender is higher than with the female gender. In science teachers' perception chemistry and physics combine feminine and masculine attributes. Accordingly, they perceive chemistry and physics as being hard, serene, clear, strong, active, sober, open, robust, ready to help, gregarious, cheerful, flexible, fresh, and healthy. It is interesting to note that comparing the teachers' perception of physics from 1998 with that of contemporary teachers illustrates the "egalitarian shift" in teachers' attribution of physics. Thus, today's teachers perceive physics as being positively related not only to the male gender but also to the female gender. In contrast, in teachers' perception the semantic profile of mathematics matches only with the semantic profile of male, but is not related to the female gender. Teachers – as do their students of both genders – perceive mathematics predominantly with masculine attributes, namely: hard, serene, clear, strong, active, sober, rigid, and robust. The current study, therefore, suggests that chemistry and physics education provides an advantageous setting for promoting gender equity in science due to the gender-equal image of these subjects among teachers. However, teachers should be aware of the masculine stereotype of physics and mathematics among students. It seems that especially in math classes female students are in danger of being disadvantaged by the gender stereotype mathematics ≠ women. The impact of "stereotype threat" (Steele, 1997; Steele and Aronson, 1995) on math ability among women as well as on women's math performance and their self-concept has been addressed in numerous studies (e.g. Spencer *et al.*, 1999; Schmader, 2002; Schmader *et al.*, 2004; Kiefer and Sekaquaptewa, 2007). Although the effect of the stereotype threat is moderated by the extent of identification with the target group, results have consistently shown the negative impact of the stereotypic image regarding women's math ability on their performance and self-concept in mathematics. It is noteworthy, however, that, of all Swiss undergraduates majoring in mathematics, 33.0 per cent were female compared to a female proportion of 18.0 per cent for physics in the academic year 2013-2014 (SFSO, 2014). Thus, the suggestion can be made that the stereotype threat to physics ability among young women is even stronger than to their math ability. Further research is needed in order to understand the influence of the gender stereotypes of math and science in the educational context on young women's career choices in STEM fields.

Conclusion

Overall, the present study provides more refined knowledge about the gender stereotype of mathematics and science in secondary education. At the same time the results of our study pose various questions for further research. First, there is a need to analyse why in the students' perception mathematics in contrast to other science subjects has no positive associations with gender, not even with the male gender. Second, the question could be raised as to why students do not share the gender equal perception of chemistry and physics reported by their teachers. Finally, further research should focus on the image of chemistry among students and teachers, as chemistry seems to hold promising potential to reduce the gender stereotype of science in education.

Our results, however, also have some limitations. Although the semantic differential employed in our study has been proven to be an appropriate and fruitful method in analysing the attributes of the gender stereotype, it is based on forced choice as to the number of selected attributes and is, therefore, limited to uncovering spontaneous connotations of science and gender. Moreover, teachers of our sample completed the semantic differential for the science subject they taught and both gender terms, whereas students completed the semantic differential for one science subject and one gender, either male or female. Thus, the reported differences between students' and teachers' perspective could have been partially influenced by this methodological bias. Finally, explicit measurements of attitudes are sensitive with respect to bias based on the social desirability of responses. Thus, the combination of the implicit and explicit methods in the assessment of respondents' gender and science stereotype should be considered in further research on gender and science stereotype among students and teachers. Last but not least, our study employed correlation analysis and is therefore precluded from claiming any causal relations.

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