International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: https://www.tandfonline.com/loi/tsed20

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To cite this article: Mingxin Liu , Weiping Hu , Shi Jiannong & Philip Adey (2010) Gender Stereotyping and Affective Attitudes Towards Science in Chinese Secondary School Students, International Journal of Science Education, 32:3, 379-395, DOI: 10.1080/09500690802595847

To link to this article: https://doi.org/10.1080/09500690802595847

International Journal of Science Education
Vol. 32, No. 3, 1 February 2010, pp. 379–395

Routledge
Taylor & Francis Group

RESEARCH REPORT

Gender Stereotyping and Affective Attitudes Towards Science in Chinese Secondary School Students

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This study explores explicit and implicit gender-science stereotypes and affective attitudes towards science in a sample of Chinese secondary school students. The results showed that (1) gender-science stereotyping was more and more apparent as the specialization of science subjects progresses through secondary school, becoming stronger from the 10th grade; girls were more inclined to stereotype than boys while this gender difference decreased with increasing grade; (2) girls tend to have an implicit science-unpleasant/humanities-pleasant association from the 8th grade, while boys showed a negative implicit attitude towards science up to the 11th grade. In self-report, girls preferred humanities to science, while boys preferred science to humanities; (3) implicit affective attitude was closely related to implicit stereotype. In particular, implicit affective attitude has a stronger predictive power on stereotype than the other way around, the result of which may have more significance for girls.

Keywords: *Gender stereotype; Attitude towards science; Secondary school student; Attitudes*

Introduction

Gender-Science Stereotypes

By "gender-science stereotypes", we mean the stereotypical association of science in general or particular sciences (e.g. physics) with one gender (e.g. male) or its correlate, the association of humanities with, for example, femininity. As a simplified and

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ISSN 0950-0693 (print)/ISSN 1464-5289 (online)/10/030379–17

DOI: 10.1080/09500690802595847

generalized construct of a complex phenomenon a stereotype can affect, often negatively, individuals' attitudes and performance (Stangor, Carr, & Kiang, 1998) and this applies equally in the case of gender-science stereotypes (DeBacker & Nelson, 2000). Gardner (1975) stated that "sex is probably the most important variable related to pupils' attitudes to science". The history of science is filled with associations, both implicit and explicit, between science and men (Nosek, Banaji, & Greenwald, 2002). Gender stereotyping in a social group may decrease girls' achievement motivation and encourage them to set lower school aspirations and lower their interest in certain subjects (Scheye & Gilroy, 1994). Mason, Kahle, and Gardner (1991) found that both boys and girls of school age have stereotyped images of science as a male domain and many studies have shown that gender differences exist in science-gender stereotypes. Boys tend to be more prone to gender-role stereotyping than girls, believing that females cannot be scientists and that they were superior to girls in mathematics and science (Chambers, 1983; Fort & Varney, 1989; Greenfield, 1997; Hong, Veach, & Lawrenz, 2003; Huber & Burton, 1995).

Other studies have found that this kind of stereotyping was influenced by age. Using the "Draw-A-Scientist" test, researchers found that older students tended to draw more stereotypical images than younger students and that the scientists drawn were predominantly male (Barman, 1997; Fort & Varney, 1989; Fung, 2002). It is evident that gender-science stereotyping has the potential to block young girls' development in science and to influence the academic and career choices of both girls and boys in science.

Attitudes

In the context of this study, "affective attitudes towards science" refers to the favourable or unfavourable feelings that individuals have about science as a school subject. According to theories on attitude development and attitude change, gender-science stereotyping as expressed in boys' or girls' beliefs about their abilities in science provides the cognitive basis of attitudes (Morrell & Lederman, 1998; Pallier, 2003). In other words, when an individual has a strong gender-science stereotype, his/her attitude towards science may mirror the expectations of the gender group. Nosek et al. (2002) used measures of implicit attitudes of college students towards science, maths, and arts and language programmes. They found that women especially showed negativity towards maths and science relative to arts and language, and that stronger implicit math/science = male stereotypes corresponded with more negative attitudes to maths for women but more positive attitudes for men.

With regard to affective attitude towards science, there is evidence of a general deterioration in affective attitudes towards science with age (Cannon & Simpson, 1985; George, 2006). Research suggests that attitudes towards science are strongly differentiated by the time a student reaches 11 years of age (Peltz, 1990). Yager and Yager (1985) found that older students were more likely than younger students to say that science was boring rather than fun and exciting, that they did not feel successful in science, and that their science class made them feel uncomfortable.

Greenfield (1997) also found that both girls and boys expressed similar attitudes towards science but younger students were more positive than older ones, and this was especially true for girls.

Gender has a significant influence on the development of science attitudes (Feist, 2006). Gender differences have been found in students' science-related affective attitudes, boys having a more positive attitude towards science than girls. Girls reported that science was difficult to understand, whereas more boys reported that science is destructive and dangerous, and therefore more "suitable" for boys (Jones, Carter, & Rua, 1999; Weinburgh, 1995). Gender differences in science-related affect appear to develop during the school years, with students experiencing many changes in factors such as anxiety, interest, and self-confidence in science. Although there is a decrease in self-confidence in both genders with age, girls have lower levels of self-confidence and they also experience more anxiety in science subjects. Furthermore, girls show a faster fall-off in interest in science than do boys in high school (Greenfield, 1997; Muzzatti & Agnoli, 2007). Thus, affective attitude seems to be closely related to the different experience of boys and girls in learning science.

The Chinese Context

It is well-documented that boys and girls get their gender cognitions and form affective attitudes towards science not only through social learning but also from direct experience and that the content of gender stereotypes varies among cultures and, to some extent, within them as well (Maccoby, 1988). The strong "preference for sons" is one of the most popular explanations for the under-representation in science of Asian women (Chen, Chen, & Liu, 2007). According to China's 1982 national fertility survey, male dominance and son preference were evident in almost every part of China (Robey, 1985) and the In-Depth Fertility Surveys in three provinces of China indicated that son preference may lead to discriminatory practices against females (Ren, 1995). Male dominance and son preference provide an obvious background to gender stereotyping. Now with the progress of the one child policy in family planning, it might be supposed that parents would expect excellence in their children equally whether they are boys or girls. However, there is very little research about gender-science stereotypes and attitudes towards science focused on Chinese adolescents. Hence, it would be useful and interesting to explore patterns of gender-science stereotyping and affective attitudes towards science in Chinese students, to extend previous research, and to understand secondary school students better.

Research Hypotheses

Based on the literature review and what is known about the situation in China, we propose the following hypotheses.

Hypothesis 1: We expect boys and girls to have similar stereotypes with science as male and humanities as female and that gender-science stereotypes would become stronger in higher grades.

Hypothesis 2: We expect that boys and girls will have a stronger implicit association of science as unpleasant, and that they implicitly evaluate science negatively compared with humanities.

Hypothesis 3: We expect that in answer to explicit questions girls will report a preference for humanities over science, while boys express a preference for science over humanities. This means that boys, but not girls, have dual attitudes towards science: while expressing an explicit liking for science, they reveal an implicit view of science as unpleasant.

Hypothesis 4: We expect that gender-science stereotyping as a cognitive component would be closely correlated with affective attitudes towards science and moreover, that implicit affective attitudes towards science would be more predictive of implicit gender-science stereotype than vice versa.

Materials and Methods

Test Materials

The Implicit Association Test. The Implicit Association Test (IAT) (Greenwald, McGhee, Schwartz, Shoda, & Attitudes, 1998) approaches attitude assessment indirectly by collecting response latencies (the time taken to reply) to category judgement tasks. The principle of the task is that it ought to be easier to pair concepts such as science or humanities with attributes or evaluations that are, in the respondent's mind, closely associated such as male or female respectively than to pair concepts with attributes that are less or not at all associated (Nosek et al., 2002). Gregg (2008) offers a useful critique of the IAT approach.

The test is administered by computer. To explore gender-science stereotyping, the screen presents, for example, "Science" and "Male" in the top-left corner and "Humanities" and "Female" in the top-right hand corner. An item (word or picture) appears in the centre of the screen and the respondent must press, as quickly as possible, one key (e.g. "Z" on the left of the keyboard) if that item is associated with one of the categories on the top left or another key (e.g. "M" on the right) if the word is associated with one of the categories on the right. Examples of items that might appear in the centre include words such as "father", "mother", "Physics", or "History". After some 60 items of this sort, the categories are reversed, Science with Female and Humanities with Male, and a parallel set of items presented. The time taken for each response is measured and slower response times (RTs) for one set is taken to indicate greater unconscious difficulty in associating that pair (e.g. science with female) together. Stronger implicit associations should lead to faster RTs for congruent pairs and slower RTs for pairs seen as incongruent (Hummert, Garstka, O'Brien, Greenwald, & Mellott, 2002). The website https://implicit.harvard.edu/implicit offers examples of IATs.

In the actual presentation of the IAT, non-scored blocks of items using only one reference category are also presented to give the respondent practice in the method of answering. Table 1 shows all of the blocks of items presented in the test of implicit gender-science stereotyping. Only blocks 3, 4, 6, and 7 provide data to be analysed. The order of presentation of the scored blocks is varied.

Table 1. Gender-science stereotype IAT procedure

Sequence	Trials	Function	Left-key response	Right-key response	Examples
Block 1	20	Practice	Science	Humanities	Physics, Chinese
Block 2	20	Practice	Male	Female	Father, Mother
Block 3	20	Practice	Science +	Humanities +	Physics, Father,
Block 4	40	Test	Male	Female	Chinese, Mother
Block 5	40	Practice	Humanities	Science	Chinese, Physics
Block 6	20	Practice	Humanities +	Science +	Chinese, Father,
Block 7	40	Test	Male	Female	Physics, Mother

In comparison to explicit measures where the subject is asked directly about their attitudes, implicit measures tend to be resistant to the influence of perceived social acceptability (Hummert et al., 2002). The consistency, stability, and convergent validity of the IAT were assessed by many researches who showed that the IAT has greater validity and reliability than other latency-based implicit measures. Internal consistency estimates for the IAT measures tend to range from 0.7 to 0.9, and test-retest reliability $r = 0.69$. The IAT also has a solid base of evidence for its construct and internal and predictive validity (Bosson, Swann, & Pennebaker, 2000; Cunningham, Preacher, & Banaji, 2001; Nosek, Greenwald, & Banaji, 2005, 2007; Schmukle & Egloff, 2004).

In this research, we also used an IAT to probe both implicit affective attitudes towards science. Each participant completed two IATs in succession which all used humanities versus science as the target-concept discrimination. For the implicit gender-science stereotyping, the concepts "science" and "humanities" were paired with "male" and "female". For the implicit attitudes to science, the concepts "science" and "humanities" were paired with the words "pleasant" and "unpleasant". Presented items included pleasant and unpleasant pictures such as some funny and comfortable animal pictures, and terrible and uncomfortable animal pictures.

The procedure and analysis of the IAT followed the recommendations of Greenwald, Nosek, and Banaji (2003) using their "*D* effect size" algorithm. The differences between a person's mean response latencies in the congruent and incongruent conditions (i.e. B6 minus B3, B7 minus B4) are divided respectively by the pooled standard deviation for B3 & B6 and for B4 & B7 and then the two quotients are averaged. The resulting IAT *D* score is conceptually similar to Cohen's *D* effect size measure indicating the direction and strength of associations between the concepts and evaluations (Greenwald et al., 2003; Nosek et al., 2007).

Explicit measures. In addition to the implicit measures described above, subjects were asked directly to express their explicit (conscious) views of science—gender associations and liking for science versus humanities. Questionnaires used were based on those of Greenwald et al. (2003). They consisted of four items: two items

testing gender-science stereotype, and two testing positive or negative feelings towards science and humanities.

To test gender-science stereotyping, participants were asked to rate the extent to which they associated science with male or female (from strongly male to strongly female), and then used the same form to rate the extent to which they associated humanities with male or female. Relative explicit stereotype was then calculated by taking the difference in responses to the humanities and science items. Positive scores represent a science = male/humanities = female association; negative scores represent a science = female/humanities = male association; a zero score represents no association of science or humanities subjects with gender.

Two items were used to test the degree to which respondents liked or disliked science and humanities. Participants were asked to rate the extent to which they like science and humanities on five-point questionnaire ranging from (1) strongly dislike to (5) strongly like. Relative degree of liking was then calculated by taking the difference in responses to the humanities and science items. A positive value indicates that the individual likes humanities more than science. For example, a participant who rated science as 1 and humanities as 5 would have a difference score of 4, indicating a relative preference for humanities.

The order in which the implicit and explicit measures were administered was randomized among the classes participating in the research.

Participants

Participants for the study were 339 7th–11th grade secondary school students in nine classes from one school in a city in Shanxi Province in China. The school has Middle and High sections. As an indication of the representativeness of the school, the Middle school is ranked 40th out of 88 schools in that city, while the High school is ranked 120th out of 240 schools. The age range of students tested was from 13 to 18 years with a mean of 15.83 years (SD = 1.77). They had no prior experience with the IAT. Following Greenwald et al. (2003), 17 (5 in implicit stereotype, 12 in implicit affective attitude) participants' scores were excluded because in their IAT data, more than 10% of trials have latency less than 300 ms or the error rate for any block of trials was greater than 39%. Thus, there are 322 valid participants (180 girls, 142 boys) in both implicit tests.

Results

Implicit Gender-Science Stereotype

Mean response latencies were calculated for both the science + male and science + female blocks. The results were consistent with Nosek et al.'s research: both boys and girls took longer to respond in the science + female condition (boys: M = 1064.6 ms, girls: M = 1113.5 ms) than in the science + male condition (boys: M = 979.47 ms, girls: M = 985.04 ms), indicating significantly stronger associations between

"science" and "male" (and between "humanities" and "female") than between "science" and "female" (and between "humanities" and "male"). For boys $t(141) = -3.97$, ($p < 0.0001$), and for girls $t(179) = -6.49$, ($p < 0.0001$).

The overall mean effect size using Greenwald et al.'s (2003) algorithm was $D = 0.241$. Sixty-one percent of participants showed this effect ($D > 0.15$), 16% showed the reverse ($D < -0.15$). The mean D scores presented in Table 2 show that implicit gender-science stereotype tendency was increasingly strong with increasing grade. Notice that mean D scores of each grade were significantly greater than zero.

Stepwise multiple regressions were conducted to test the main effects of gender (coded 1 for girls, –1 for boys), grade, and their interaction on implicit stereotype. Main effects of gender and grade were observed, but there was no significant interaction between gender and grade. The standardized regression equation was:

$$Z\ (\text{implicit gender} - \text{science stereotype}) = 0.301(\text{grade}) + 0.108\ (\text{gender}).$$

Regression coefficients were significant ($p < 0.0001$, $p < 0.05$, respectively). Combined with Figure 1 which presents the mean D values across grade and gender, it is evident that students in higher grades have stronger implicit science = male stereotypes than lower graders, and that girls' stereotypes were stronger than boys, while this gender difference becomes smaller at higher grades.

Explicit Gender-Science Stereotype

Scores for explicit gender-science stereotypes were represented by the difference score of (humanities = male) minus (science = male) in the self-report questions. Because positive scores represent a science = male/humanities = female association, negative scores represent science = female/humanities = male association, and zero represents science and humanities subjects have no association with gender, a one sample t-test was conducted and found scores across 7th–11th grades were significantly higher than zero. This suggests that the explicit stereotype of science = male/humanities = female exists in 7th–11th grades, but there is no significant gender difference (Table 3).

Table 2. Mean D scores across grades on IAT for science-gender stereotype (D_{sg})

	Grade				
	7th	8th	9th	10th	11th
D_{sg}	0.101	0.150	0.161	0.292	0.408
df	63	56	54	51	93
t	2.04*	3.40**	3.24**	6.02***	11.11***

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

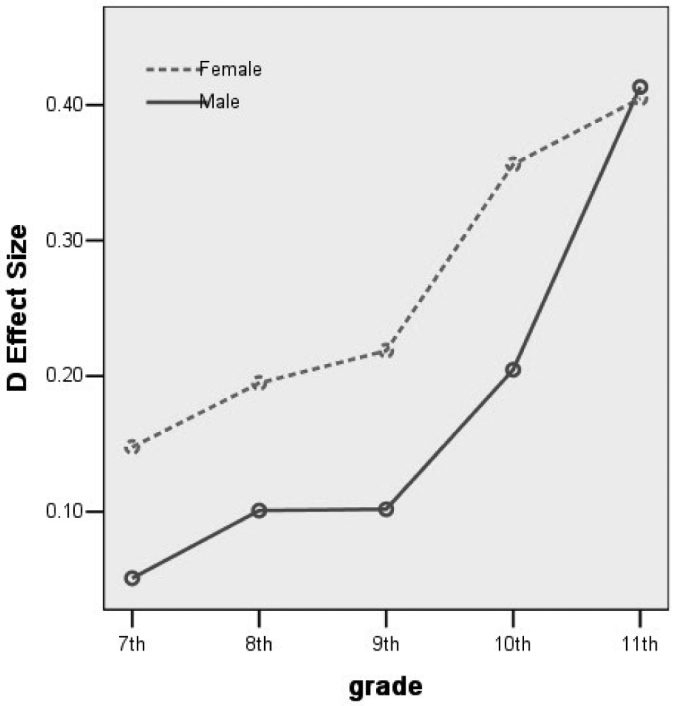

Figure 1. Sub-group mean *D* for implicit gender-science stereotype

Implicit Affective Attitude Towards Science

Mean response latencies were calculated for both the science + unpleasant and science + pleasant blocks. Both boys and girls took longer to respond in the science + pleasant condition (boys: M = 1077.19 ms, girls: M = 1174.20 ms) than in the science + unpleasant condition (boys: M = 1034.34 ms, girls: M = 1072.30 ms), indicating that science + unpleasant/humanities + pleasant was the congruent association and science + pleasant/humanities + unpleasant was incongruent association. However, the effect was only significant for girls: $t(179) = -4.74$, $p < 0.0001$. For boys there was no significant effect (see Tables 4a and 4b).

Table 3. Mean scores on the explicit gender science stereotype questionnaire by grade

	Grade				
	7th	8th	9th	10th	11th
M	1.47	1.25	1.73	2.08	1.53
d*f*	63	56	54	51	93
t	6.23***	5.66***	8.23***	9.70***	12.40***

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

Table 4a. Mean *D* scores across grades on IAT for boys' attitudes to science (D_{att})

	Grade				
	7th	8th	9th	10th	11th
D_{att}	0.12	0.03	0.05	0.04	0.22
d*f*	30	26	26	21	34
t	1.95	0.54	0.91	0.63	3.94***

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

Figure 2 presents the mean *D* effect across grade and gender. Fifty-four percent of participants showed an effect with $D > 0.15$, while 15% showed the reverse ($D < -0.15$). The strongest IAT effect magnitude was observed in girls, who showed the greater difficulty of pairing science with pleasant pictures and humanities with unpleasant pictures compared to pairing science with unpleasant pictures and humanities with pleasant pictures (mean $D = 0.22$).

Stepwise multiple regressions were conducted to test the main effects of gender (coded 1 for girls, –1 for boys), grade, and their interaction on implicit attitude. Main effects were found for grade and for gender×grade interaction, but none for the variable of gender. The standardized regression equation was:

$$Z \text{ (implicit attitude towards science)} = 0.161(\text{gender} \times \text{grade}) + 0.130 \text{ (grade)}.$$

Regression coefficients were significant ($p < 0.005$, $p < 0.05$, respectively). The data shown by grade in Figure 2 suggests that although there is an overall trend towards science over the period from Grade 7 to 11, students reported feeling more positive about science in the middle years (Grade 8–10) than at the start or completion of their secondary schooling.

Further examination of the gender×grade interaction revealed that the mean *D* score for girls in 8th–11th grade was significantly non-zero, with the exception of 7th ($t(32) = 1.59$, $p = 0.12$; $t(29) = 4.26$, $p < 0.0001$; $t(27) = 4.38$, $p < 0.0001$; $t(29) = 3.37$, $p < 0.005$; $t(58) = 6.93$, $p < 0.0001$, respectively). This shows that

Table 4b. Mean *D* scores across grades on IAT for Girls' attitudes to science (D_{att})

	Grade				
	7th	8th	9th	10th	11th
D_{att}	0.09	0.27	0.20	0.19	0.30
d*f*	32	29	27	29	58
t	1.59	4.26***	4.38***	3.37**	6.93***

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

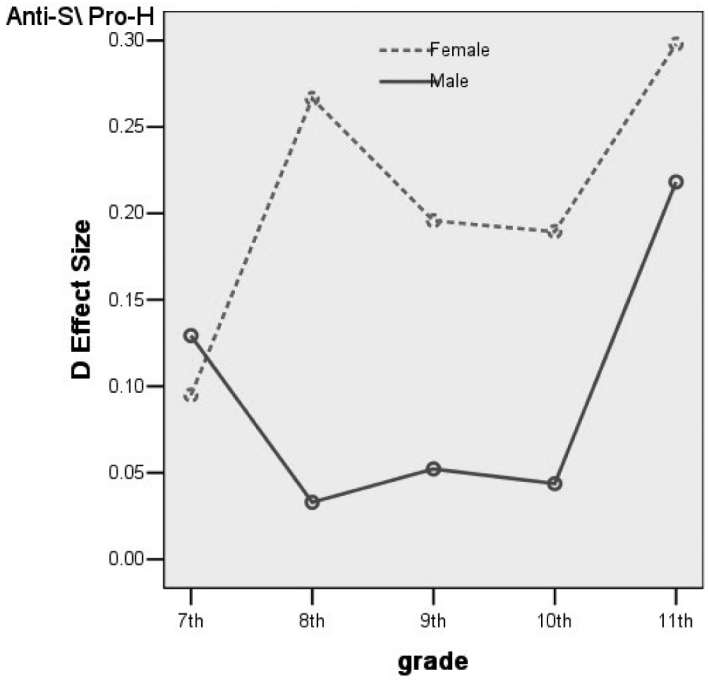

Figure 2. Sub-group means for implicit affective attitude toward science
Note: S = science, H = humanities

for girls the tendency of anti-science/pro-humanities was in evidence from 8th grade, but for boys, a negative attitude towards science does not appear until the 11th grade.

Explicit Affective Attitude Towards Science and Humanities

Scores in explicit affective attitudes towards science and humanities were represented by the difference score in responses to the humanities and science items. Figure 3 shows the mean scores across gender and grade. Positive values indicate that an individual likes humanities more than science. There was a gender difference for the whole sample: boys: $M = -0.37$, girls: $M = 0.38$, $t(320) = 3.825$, $p < 0.0001$. Figure 3 shows that this trend is also true at each grade except 9, where girls are more favourable to science than boys. This could be a local effect due to particular influences in the one school which provided the sample.

Correlation Between Implicit and Explicit Variables

A positive correlation between implicit and explicit attitudes would indicate that a stronger implicit (supposedly unconscious) preference for one object was associated with (and possibly related to) a stronger explicit preference for the same object

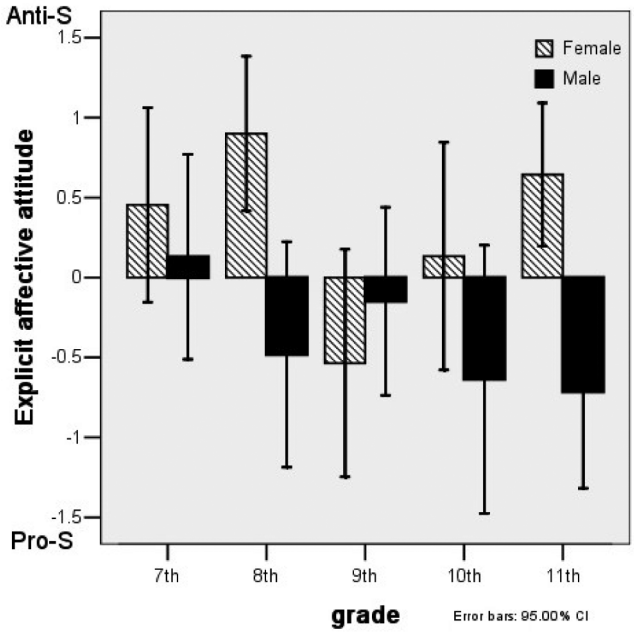

Figure 3. Attitude towards science by grade and gender
Note: Positive scores represent anti-science/pro-humanities

(Nosek, 2005). None of the correlations between implicit and explicit gender-science stereotyping across gender and grade presented in Table 5 are significant, but all are positive with the exception of the 9th grade girls.

Table 5 also shows that significant correlations between implicit and explicit affective attitude towards science only appeared in girls of high school age (10th and 11th grade). Combined with Figure 3, we can see that girls, with the exception of 9th grade girls in the explicit test, expressed similar negative attitude towards science in both implicit and explicit tests.

Table 5. Correlation between implicit and explicit variables

	Gender	7th	8th	9th	10th	11th
Implicit and explicit stereotype	Male	0.231	0.184	–0.001	0.217	0.209
	Female	0.057	0.013	–0.239	0.057	0.132
	Total	0.126	0.140	–0.116	0.107	0.165
Implicit and explicit Affective attitude	Male	0.187	–0.158	0.058	–0.059	0.133
	Female	–0.062	–0.033	–0.205	0.587**	0.236*
	Total	0.159	0.056	–0.100	0.339*	0.225*

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

The Relationship Between Implicit Stereotype and Affective Attitude

Correlations between implicit stereotype and affective attitude towards science shown in Table 6 indicate that significant correlations only appeared in girls of 7th, 10th, and 11th grades. The closer they associated science with male, the stronger their negative attitude towards science was.

Results of the implicit affective attitude test showed that a negative attitude towards science appeared for girls in the 8th grade which is just the time that physics is added to curriculum. Stereotypes are likely to be present in the environment before an individual forms a personal attitude towards science, but the magnitude of stereotype was a function of grade, that is, an attitude towards science formed through direct experience in science subjects may strengthen or weaken the gender-science cognition. To test whether implicitly stereotyped cognition could be predicted by implicitly affective attitude or vice versa, regressive analyses were conducted separately. Evidence from two implicit tests showed that gender and grade were two important factors in implicit stereotype and affective attitude towards science. Results from the explicit tests have some significance, but they are likely influenced by consciousness or social desirability so were not included in the regression. Gender, grade, implicit variables and their interaction were analysed.

In predicting implicit attitude, the interactions of gender×stereotype and grade×stereotype were entered the regression equation. The standardized regression equation was:

$$Z\ (\text{implicit attitude}) = 0.273\,(\text{grade} \times \text{stereotype}) + 0.26\,(\text{gender} \times \text{stereotype}).$$

Regression coefficients were significant ($p < 0.0001$, $p < 0.0001$, respectively). About 15.8% of the variation in implicit attitude towards science can be explained by the regression model. In predicting implicit gender-science stereotype, the findings indicated that the interactions of gender×attitude, grade×attitude and grade entered the regression equation. The standardized regression equation was:

$$Z\ (\text{implicit gender} - \text{science stereoty}) = 0.225\ (\text{grade} \times \text{attitude}) + 0.29\ (\text{gender} \times \text{attitude}) + 0.212\ (\text{grade}).$$

Table 6. Correlation between implicit stereotype and affective attitude

Gender	7th	8th	9th	10th	11th	Total
Male	−0.353	0.087	0.008	0.213	0.040	0.000
Female	0.365*	0.223	0.275	0.564***	0.584***	0.445***
Total	−0.016	0.202	0.164	0.447***	0.321**	0.256**

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

Regression coefficients were significant ($p < 0.0001$, $p < 0.0001$, $p < 0.0001$, respectively). About 20% of the variation in implicit gender-science stereotype can be explained by the regression model.

This regression analysis indicates that a stronger stereotype was closely related to a more negative attitude for girls than boys, and for higher graders more than lower graders. The predictive power of attitude on stereotype was higher than that of stereotype on attitude.

Summary of Results

Limitations of the Study

Before summarizing the results obtained and their implications for science education, some limitations of this study should be highlighted. Firstly, the sample was only from one school in Shanxi province, limiting both power and generalization. It is claimed that there was nothing "special" about this school (e.g. it was not a "key school") and as indicated earlier it was a middle-ranking school in a typical city in one central province of China. However representative the school may be, there is always the possibility that specific local factors, such as a particularly charismatic or particularly dull teacher could unduly influence our findings relating to attitudes to science. This is a possible explanation for the anomalous results for Grade 9 girls.

Secondly, the current study highlighted only pleasant/unpleasant affective attitudes to science in the implicit test. Other affective components from science such as feelings of excitement and self-confidence about science (Jones et al., 1999; Muzzatti & Agnoli, 2007; Weinburgh, 1995) were not included.

The results summarized below should be read with these limitations in mind.

Results Related to the Hypotheses

Firstly, the results regarding gender stereotyping of science partly support the Hypothesis 1 that students in 7th–11th grades implicitly viewed science as a male domain and humanities as a female domain, and this kind of gender-science stereotype appeared to be more and more apparent during the secondary school years. This positive grade effect is important finding-adding to evidence reported by Nosek et al. (2007). Girls' stereotype was stronger than boys from 7th grade, whereas gender difference got smaller as increasing grade. This result did not support the content of Hypothesis 1 about no gender difference in stereotype. But it extended the results in Nosek et al. (2002, 2007), in which they observed a lack of gender effect, participants in their researches were college students and internet volunteers ($M = 26$ years old, $S = 10.7$), whereas participants in the current research were all secondary school students, as grade tendency showed, current results did not conflict with previous researches.

Secondly, the results partly supported Hypothesis 2 that girls have stronger implicit science-unpleasant/humanities-pleasant association from 8th grade, but

unexpectedly boys showed a negative implicit attitude towards science until the 11th grade. Consistent with previous reports, girls have more negative attitude towards science than boys. This contrasts with Nosek et al.'s (2002) findings that college boys showed the same negative attitude towards science as girls, while the middle school boys in our sample do not appear to differentiate in attitude towards science and humanities until the 11th grade, which seems to be a turning point for boys' implicit affective attitude towards science.

Thirdly, different responses to probes of implicit and explicit attitudes supported Hypothesis 3 and indicated that boys held dual attitudes towards science, as proposed by Wilson, Lindsey, and Schooler (2000). They showed no differentiation in implicit attitude towards science and humanities in Grades 7–10 and a negative attitude in Grade 11, while they claimed positive attitudes towards science throughout in the explicit test.

Finally, as Hypothesis 4 expected, implicit affective attitude was related to stereotype although the correlation was not consistent across all grades and both genders. A stronger stereotype was related to more negative attitudes for girls than for boys and for higher graders than lower graders. Implicit affective attitude was more strongly predictive of science-gender stereotype than the other way around. These results from older students with stronger implicit stereotypes and more negative attitudes towards science than younger students are consistent with past researches (Barman, 1997; Feist, 2006; Fort & Varney, 1989; Nosek et al., 2007). It is obvious that the variable of grade has an important effect on both implicit stereotype and attitude.

Discussion

In discussing the results, we will look separately at grade effects and at gender differences.

The grade effects reported here may plausibly be related to the nature of the science curriculum and to the shift from a more laissez-faire approach at the elementary level to one which focuses on performance and grades. In China, the content of the science curriculum in elementary school is concerned primarily with the cultivation of interest in science. There is little specialization and no high-stage testing of content knowledge. Elementary students experience little performance pressure and are liable to have a positive or relaxed feeling towards science as a school subject. In contrast, science curricula in secondary schools are increasingly specialized. Students begin to study biology in 7th grade, physics in 8th grade, and chemistry in 9th grade. They experience an increased focus on mastery of scientific knowledge and more demands are placed on them to perform well in tests. In these respects, China is similar to many other countries in the world, and it is unsurprising that the results here indicate a similar trend with age in attitudes turning against science as a pleasant subject.

Turning to the issue of gender, in addition to the pressure from increasing amount of science-related work loads with increasing grade, the experience of boys and girls can be different in important ways. Jovanovic and King (1998) showed that over the

first year in middle school, where an emphasis on performance starts, there was a decrease in girls' perception of their own science ability while boys' experience was just the opposite. Girls reported that science was difficult to understand, whereas more boys reported that science was more "suitable" for boys (Jones et al., 1999; Weinburgh, 1995). As a consequence of this differential response to competition, it seems most likely that girls' interest in science will be negatively influenced and in this way the male-science/female-humanities stereotype is engendered. This is a case of a small initial effect becoming multiplied as a self-fulfilling prophecy. As results reported here indicate, boys' own gender-science stereotype now develops and strengthens and eventually the gender difference in stereotype get smaller as the stereotype reinforces itself. The more negative attitude towards science the girls had, the stronger the male-science stereotype develops.

It was interesting to note that only for boys, dual attitudes towards science appeared. In the implicit test, no difference in attitude towards science and humanities was shown before Grade 11, while in the self-report boys claimed that they preferred science to humanities. In the 11th grade, boys showed the same implicit negative attitude as girls, which was consistent with results in Nosek et al. (2002). This suggests that boys are affected by the stereotype that science is a male domain and that their response was affected by stereotyped cognition. They wanted to be seen as having gender consistent preference for science, especially in Grade 11.

An affective attitude towards science can not only mirror one's experience of science or expectations for males and females, but also weaken or strengthen one's stereotype. The finding that girls' stereotypes seemed to appear prior to their negative attitude towards science mirrors, to a certain extent, the stereotyped cognition in their living environment. Research shows that expectations heavily influence academic performance (Spencer, Steele, & Quinn, 1999). If expectations of society and important people are unprejudiced and if a school environment makes no expectation (explicit or implicit) of different performance by boys and girls in science, girls will have a chance to perform as well as boys (Muller et al., 2005). Conversely, if girls experience more negative affects such as unhappiness in science classrooms and do not get sufficient attention from the teacher, their inappropriate science-gender stereotype will be gradually strengthened. As a kind of information, affect influences cognition (Forgas & Fiedler, 1996).

The significance of these findings can be read as meaning more for girls than for boys. Specifically, entering the science domain with a positive affective experience and interest could allow girls to study intensively and then success on performance criteria will counter the formation of science ≠ female stereotypes.

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