

Assessing Implicit and Explicit Math-gender Stereotypes in Chinese adults

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Abstract. The questionnaires and Implicit Association Test were used to investigate the explicit and implicit Math-gender stereotypes of Chinese college students, which refers to the implicit notion that men are better at mathematics than women and women are better at reading than men. It was found that there was no explicit Math-gender stereotype overall, but there was clearly an implicit Math-gender stereotype.

Keywords: Implicit; Explicit; Math-gender Stereotypes.

1. Introduction

Gender stereotypes have been found to affect mathematics attitudes, engagement, motivation, and identity (Steffens & Jelenec, 2011). It leads to detrimental consequences in females particularly. For example, females with strong gender stereotypes have less performance and interest in math (Davies et al. 2002; Gresky et al. 2005; Lesko & Henderlong Corpus 2006; Spencer et al. 1999), and are often related to their career choices (e.g., Eccles 1994). In many countries, women are still underrepresented in math-intensive careers and earn only a small percentage of university diplomas in these fields (Ramm and Bargel 2005)

Explicit attitudes are psychological deposition for or against a social group or an event or an opinion and inevitably influence an individual's behavior to some extent (Greenwald & Banaji, 1995). In the 1990s, American psychologists Greenwald and Banaji proposed a new field of research, implicit social cognition, based on analyzing a large body of research literature. The research in this field clearly showed that attitudes have both a conscious and an unconscious side (Greenwald & Banaji, 1995). Implicit stereotypes may be triggered rapidly and automatically without the individual's consent, and they can influence conduct without their awareness (Greenwald & Banaji, 1995). A distinction is made between so-called explicit and implicit attitudes. This is particularly true for Math-gender stereotypes, with both implicit and explicit attitudes in them. Therefore, this investigation includes an explicit questionnaire and an implicit association test (Greenwald et al. 1998), which is commonly used to measure implicit attitudes accumulated using reaction-time.

The Math-gender stereotype refers to the belief that many people think that females are less capable of learning mathematics and some closely related subjects than males (Steffens & Jelenec, 2011). Over the past decades, Math-gender stereotypes have been found to be widespread in both western and eastern countries (Liu, 2018). In Liu's experiment, she used data from the Chinese education panel survey to investigate the contradiction between a diminishing gender gap in math achievement and a persisting gender stereotype in STEM. Measures of gender-math stereotypes from Chinese students, parents, and classmates are included in this article.

Mathematics is not only an essential subject, but to some extent, it is also the foundation for many other subjects. In the general environment of China, it is expected that there are fewer girls in math-intensive majors, and many girls majoring in humanities and arts in universities. There are far fewer women than men who have achieved high levels of success in the STEM field. It is evident that the Math-gender stereotype in the educational climate is not a positive one.

Taken together, the present research aims to explain the explicit and implicit Math-gender stereotype of Chinese college students. We examined both implicit and explicit Math-gender stereotypes among a group of Chinese adults. Given the previous work, we hypothesized that

participants will show implicit and explicit gender stereotypes; male versus female participants differ in gender stereotypes and whether there is a correlation between implicit and explicit attitudes.

2. Method

2.1 Subjects

The subjects were 32 Chinese with education levels ranging from high school to graduate students. Among them, 17 were male, and 15 were female (approximately ages 22-24 years). Twenty-two were college students, and 10 were graduate students. All subjects volunteered to participate and were familiar with cell phone operations. As part of the pre-participation consent process, subjects were informed and reminded that they were free to withdraw at any time. Participants were recruited via one IAT experiment and follow-up questionnaires.

2.2 Procedure

Upon participants' consent, implicit gender-math stereotypes, explicit attitudes and beliefs towards gender stereotypes, and basic demographic information were measured. Implicit gender-math stereotypes were measured via the Implicit Association Test (IAT). The IAT is an implicit association test proposed by Greenwald et al. The IAT is a complex test that provides a susceptible and valid measure of an individual's implicit cognition. This test measures the closeness of the automatic association between two types of words (conceptual and attribute words) through a categorization task and subsequently measures the individual's implicit attitude. The main reasons for using IAT in implicit Math-gender stereotype research are the following advantages: First, IAT is highly adaptable, and it can be used to express most concepts in the form of words or pictures so that it can measure a variety of implicit attitudes, stereotypes, and concepts. Second, IAT is very straightforward to administer, as the entire experiment is done independently by the participants on the computer or electrical devices and can be tested individually or in groups. The concept words in this experiment were divided into mathematics and reading, and the categories of attribute words were male and female. Explicit gender stereotypes were also measured via a 7-items questionnaire. The experiment was conducted on a touch screen device (e.g., phone, tablet).

2.3 Implicit Association Test (IAT)

The steps of the IAT test for implicit Math-gender stereotypes are (Greenwald et al., 1998): (a) initial target-concept discrimination for concept word practice (math/reading), 24 attempts, equivalent to 2 practice sessions for each word; (b) evaluative attribute discrimination was an attribute word (boy/girl) exercise, with 23 attempts, equivalent to 2 practice sessions for each word; (c) first combined task was a congruent task (boy&math/girl & reading), with 36 attempts, and the results recorded in this step were taken as the raw data for statistical analysis; (d) reversed combined task was another exercise of the concept words, identical to trial two except for the opposite of touch screen; (e) reversed combined task was an incongruent task (girl & math/boy & reading), with 36 attempts, and the results recorded in this step were taken as the raw data for statistical analysis. During the practice phase, the participant was prompted to give feedback when making an error in the center of the screen and to continue by clicking on the other side of the screen. In the combined task, if the subject made a response error, no feedback was given, and the subject was not asked to make changes, and the trial continued.

2.4 Explicit Attitude Measures

At the end of the IAT, subjects completed a follow-up questionnaire measuring their attitudes toward gender stereotypes of mathematics. There were seven questions in total, six of which used a Likert scale of 1 (never)-5 (frequently), and one question was an open-ended response that allowed participants to provide multiple possibilities. Several questions addressed participants' opinions, such

as gender stereotypes associated with boys/girls with math or reading, gender-stereotyped beliefs about ability, gender stereotyped differences about ability, participants' own gender stereotypes experience, agreement, and opinion.

3. Results

3.1 Descriptive Statistics

Descriptive results were presented below in Table 1 (female participants) and Table 2 (male participants).

Table 1. Descriptive results for female participants

Variable	Participants number	Mean	Std.Dev	P value
Agree-ability	15	2.93	1.033	0.428
Agree-difference	15	2.67	1.175	0.338
Degree-stereotype	15	3.80	1.082	0.196
Experience-stereotype	15	3.27	0.884	0.066
female-reading	15	3.33	1.175	0.007
Male-math	15	3.36	0.91026	0.003

Table 2. Descriptive results for male participants

Variable	Participants number	Mean	Std.Dev	P value
Agree-ability	16	2.56	1.504	0.433
Agree-difference	16	2.31	0.793	0.442
Degree-stereotype	16	3.19	1.471	0.199
Experience-stereotype	16	2.56	1.153	0.068
female-reading	16	2.13	1.147	0.007
Male-math	16	2.25	1.34164	0.003

3.2 Prescriptive Statistics

Implicit Gender Stereotypes

We analyzed the implicit attitude measure following standard protocol for the improved scoring algorithm recommended by Greenwald, Nosek, and Banaji (2003). In a total of 48 participants, only 32 participants finished the IAT. Calculation of response-time means and IAT effects and d-values (mean/standard deviation of IAT effects) for congruent trial (math-related pictures correspond to boys and reading-related pictures correspond to girls) and incongruent trial (math-related pictures correspond to girls and reading-related pictures correspond to boys) in the IAT test.

Response latencies (in milliseconds) and error rates were recorded for each trial block. We used a one-sample t-test to examine if individuals had any implicit gender stereotypes. Implicit D scores were found to be not significantly different from zero, $t(31) = 1.56$, $p = .130$. This result suggests that participants displayed implicit gender stereotypes.

Afterward, we used an independent sample t-test to investigate if boys and girls had distinct implicit gender stereotypes. we found no significant difference between boys and girls, $t(30) = -1.51$, $p = .141$.

3.3 Explicit Gender Stereotypes

To examine whether participants had significant gender stereotypes associating boys/girls with math or reading, we calculated the mean score and compared it to 3 (baseline). One sample t-test showed that the result was not significant, $M = 2.74$, $t(31) = -1.114$, $p = 0.274$. Taken together, this indicated that many of the participants had neutral gender-math attitudes. Meanwhile, participants believed that there are stereotypes in the math field, $M = 3.48$, $t(31) = 4.171$, $p < 0.001$, they were significantly different.

The majority of participants also showed that they had experienced the Math-gender stereotype. In the one-sample t-test, $M = 2.9$, $t(31) = 2.087$, $p = 0.045$, we could interpret that because the baseline stands for 3, and participants were bearing gender stereotypes regarding math.

Finally, we computed the independent sample t-test data and concluded that overall p values were not significantly different. The last two items (male-math/female-reading) showed some significant differences. Both p values were smaller than 0.05, which implied that boys and girls think differently. In this case, our baseline was 3 (no idea).” Boys are more likely to choose “generally do not associate girls with languages,” $M = 2.13$, $p = 0.007$. However, girls showed that they would associate girls with reading because the mean score was bigger than 3. In the question where we asked about their attitudes associating male with math, participants responded similarly to the last one. Boys were more likely to choose “no,” but girls were more likely to choose “occasionally.”

3.4 IAT Compared with Explicit Measures

Correlations among the explicit and implicit attitude measures are shown in Table 3. As we can see in the table, the implicit and explicit measures were not exactly correlated with each other. Notably, however, scores on male/math related variables were significantly different, $p = 0.038$, $p = 0.08$, $p = 0.04$, $p < 0.001$. We can interpret that, to a large extent, participants believed boys are better than girls in math, they are more likely to also agree that boys and math should be associated with each other.

Table 3. Correlations among the explicit and implicit attitude measures

	IATDScore	1	2	3	4	5	6
Agree-ability	0.620	-	-	-	-	-	-
Agree-difference	0.484	0.115	-	-	-	-	-
Degree-stereotype	0.621	0.248	0.095	-	-	-	-
Experience-stereotype	0.065	0.043	0.683	<0.001	-	-	-
Female-reading	0.462	0.110	0.458	0.126	0.189	-	-
Male-math	0.411	0.038	0.460	0.008	0.004	<0.001	-

4. Discussion

Gender stereotypes about math are important predictors of individuals’ attitudes and beliefs about math, such as self-perception of ability, self-confidence, task-value, and interest (e.g., Lane, Goh, & Driver-Linn, 2012). The present study aimed to investigate gender stereotypes about math among Chinese college students both at the implicit and explicit levels. We found that participants showed Implicit math gender stereotypes, such that they associated boys with math and girls with reading. Meanwhile, Mixed results have been found in terms of explicit gender math stereotypes. First participants associated math and reading equally with boys and girls. However, they believed there are gender stereotypes in the math field and that they reported experiencing gender stereotypes themselves. Also, Implicit and explicit gender math stereotypes are not correlated with each other.

In the previous study, for example, children in Ambady et al. (2001)'s study used an implicit measure that did not rely on the IAT, and the result showed that both boys and girls had Math-gender stereotypes. With the same as this study, both females and males' participants displayed the implicit gender stereotypes in math.

Noticeably, Ambady et al. (1999) American psychologists Shih, Pittinsky, conducted a study in which they took 46 Asian female college students and divided them into three groups by computerized random drawing, each completing a math ability test. All three groups of women were given the same math questions, except for the instructions they received before taking the test. In the first group, they were reminded of the fact that "you are female"; in the second group, they emphasized the fact that "you are Asian"; and in the third group, they did not deliberately emphasize their gender or race. When the results came out, everyone was stunned: the same test, randomly grouped into 3 groups of college students, but the results were very different. The first group had the worst score, 43 points; the second group had the best score, 54 points; the third group had a medium performance, 49 points. When these students were stressed "you are girls", the self-bias of "girls are worse at math" was activated, which led to a significant drop in math scores. When these students were stressed "you are Asian", the self-bias of "Asians are better at math than whites" was activated and their scores genuinely improved by several steps. Finally, a third group of students, who were not reminded of either their female gender or their Asian racial identity, scored right in the middle groups in math.

As we can see, there is no correlation between implicit attitudes and explicit attitudes in the Math-gender stereotype of Chinese college students. Also, this dissociation was observed to suggest that implicit and explicit attitudes need not be congruent at 6-year-old age children (Baron & Banaji 2006). Racial attitudes were measured in White Americans at ages 6, 10, and adulthood in order to better understand the development of implicit views. This stereotype was obvious even in the youngest groups, according to the findings. For the first time, their findings indicate an imbalance between implicit and explicit attitudes.

Greenwald (et al. 1998) pioneered a study of Black, White racial stereotypes using the Implicit Association Test. They designed a test using some typical black surnames and white surnames and adjectives, including positive and negative words as materials. The results found that the response time of the incongruent trial was significantly longer than the congruent trial, which indicated that people were more likely to associate Whites with good attributes and Blacks with bad attributes, confirming the existence of racial implicit stereotypes, and also found that there was relative independence between racial implicit stereotypes and the corresponding measures of explicit stereotypes. Also, Greenwald (et al. 1998) examined the attitudes of Japanese Americans and Korean Americans toward the Japanese and Korean ethnic groups and found a significant ingroup and outgroup effect, they were more likely to associate happy words with names that had characteristics of their ethnic group and unhappy words with names that had characteristics of the other ethnic group. The differences between ingroup attitudes were more significant than those between outgroup attitudes.

This experiment explored Math-gender stereotypes. Reducing these stereotypes can mitigate negative effects on female mathematics performance (Lane, Goh, & Driver-Linn, 2012). The experiment results indicated that people have implicit Math-gender stereotypes, but for explicit attitudes, some have and some do not have these stereotypes. In addition, the implicit and explicit attitudes were more pronounced for females than males. Moreover, implicit and explicit are not correlated; they are two different systems. Intriguingly, this experiment also displayed an interesting result that the LGBTQ community had almost no gender stereotype in math among other participants. In this study, we wish to understand the larger population of our sample size; however, we only conducted a study with 31 participants. The larger the sample size, the more precise the relationship shows.

The existence of stereotypes also creates a lot of anxiety about this belief, as well as questions and threats to identity. When this stereotype occurs in a group of individuals in a negative area, for example, females have "poor math skills," which makes them perform poorly in math. When this

stereotype threatens math, it can also lead to lower performance in other areas of experience or performance. This threat hinders and affects people's performance in essential areas and causes the threatened individuals to show corresponding negative consequences. In order to be able to activate the identity of positive stereotypes, future research should also pay more attention to the exploration of methods and their application in real life.

When a dominant group discriminates against another disadvantaged group, the latter will not only be discriminated against by the powerful group, but even they themselves will carry the same prejudice and belittle themselves. Through this experiment, we found that both implicit and explicit attitudes are deeply present in people's perceptions. In the future education area, educators should teach students the definition of stereotypes from a young age. Since we cannot try to disappear its existence, we should accept it and acknowledge it.

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