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Whether your name is Manuel or María matters: gender biases in recommendations to study engineering

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ABSTRACT

A controlled experiment was conducted to detect gender biases that participants, acting as advisers, may have when providing guidance to teenagers on their career choice. We presented a fictional profile to the study participants – university students from Spain – of a 15-year-old person, called Manuel or María, with two possible levels of academic record. The participants were asked to evaluate the student's mathematical ability and provide guidance regarding whether or not he or she should study engineering in the future. We assumed that the effect of being a male target on the recommendation to study engineering is partially mediated by the fact that the participants attribute a greater mathematical ability to males. Our results suggest that a significant degree of gender bias in favour of males persists in the recommendation to study engineering. We propose some practical implications for advisers and for equality policies.

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Career recommendations; STEM careers; engineering; gender bias; double standards

Introduction

Overall, women remain under-represented in engineering and technology. In Spain, they represented 24% of the engineering and technology research staff in public universities in 2017 (MCIU, 2017). These figures are consistent with low female enrolment rates in courses in this field. For example, in Spain women represented 21.2% of the total number of students enrolled in mechanical engineering in the 2016-2017 academic year, and 11.9% of those enrolled in computer engineering (MECD, 2018). This gap is even higher when looking at expectations. According to the 2018 PISA data for Spain (OECD, 2020), at age 15 far fewer girls (6.1%) than boys (23.8%) reported that they expect to have a career in engineering or computing. This result is very similar to the OECD average for all countries (OECD, 2020).

Research shows that the disadvantage faced by girls in technological STEM is the result of the interaction of a range of factors embedded in both the socialization and learning processes (Moote, Archer, DeWitt, & MacLeod, 2019). As suggested by the expectancy-value theory (Eccles et al., 1983) and the ecological framework (Bronfenbrenner, 1979), these include social, cultural and gender

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norms which influence the way girls and boys are brought up and how they learn and interact with parents, family, friends, teachers and the community at large, which all shape their identity, beliefs, behaviour and choices (UNESCO, 2017). Moreover, mathematical ability is considered a prerequisite for students wanting to enrol in technological courses (Sáinz & Eccles, 2012), in a context in which maths-gender stereotypes persist that put girls at a disadvantage (Cheryan, 2012; Shapiro & Williams, 2012; UNESCO, 2017).

The beliefs and expectations of parents, teachers and other advisers can have an important effect on mathematics self-concept and on the career choice of girls and boys (Gunderson, Ramírez, Levine, & Beilock, 2012). However, the beliefs, attitudes and expectations of advisers are themselves influenced by gender stereotypes or, in the words of Charles and Bradley (2009, p. 925), by "the enduring cultural force of gender-essentialist ideology (i.e. cultural beliefs in fundamental and innate gender differences)".

In this research, following the Status Characteristics Theory (Correll & Ridgeway, 2003; Foschi, 2001), we focus specifically on the detection of possible biases, derived from the existence of these stereotypes, that advisers (parents, teachers, school counsellors, older siblings, etc.) may have when assessing the mathematical ability of teenagers or when advising them on their career choice. Our study has three research aims: first, to capture and quantify experimentally the bias exerted by potential advisers in favour of a young male target compared to a young female target in the recommendation to study engineering. Second, to detect and quantify the gender bias in favour of the male target in the attribution of mathematical ability. Third, to determine to what extent the bias in the recommendation to study engineering is related to the bias in the attribution of mathematical ability.

For this purpose, we conducted a controlled experiment to directly detect these biases. We presented a fictional profile of a 15-year-old person to the participants in our study (university students from Spain who were asked to act as if they were advisers of this teenager) and asked them to evaluate his/her mathematical ability (compared to verbal expression and communication) and advise him/her about whether or not to study engineering in the future. We used a 2×2 factorial design where factor 1 was the gender of the target (male, female) and factor 2 was the target's level of academic record (intermediate, high).

After a random assignment of the participants to each of the four resulting experimental conditions, we were able to obtain causal evidence regarding the biases discussed previously. The fact that the target was called Manuel or María causally influenced the evaluations and recommendations of the participants.

We consider that the present research makes two novel contributions to the literature on gender and the choice of a STEM career. On the one hand, it provides a new line of research on the gender biases of advisers; on the other, from a methodological point of view, it provides a new instrument to detect the effect of gender stereotypes on the recommendations of advisers.

Stereotypes and social role theory

The analysis of the influence of advisers on the choice of courses taken by adolescents can be addressed through the expectancy-value theory (EVT) (Eccles, 2014; Eccles et al., 1983, 1993) and the "ecological framework" (Bronfenbrenner, 1979; Bronfenbrenner & Evans, 2000). Both theoretical approaches distinguish a series of overlapping factors – society, school, family, peers, and learner – that influence the participation, achievement and progression of girls and women in STEM studies (UNESCO, 2017). In both cases, what stands out is that advice from parents, teachers, school counsellors, older siblings, etc. can play an important role in the child's perceptions and choices. In this regard, there is considerable literature that confirms the influence of parents and other counsellors in the formation of adolescents' attitudes to mathematics and the course of study they choose (Boudarbat & Montmarquette, 2009; Davis-Kean, 2005; Eccles, 2014; Eccles et al., 1993; Jodl, Michael, Malanchuk, Eccles, & Sameroff, 2001; Sáinz & Müller, 2018).

The problem is that a series of gender stereotypes persist in society and these, logically, are also held by the advisers, who subsequently make biased recommendations to adolescents (Sáinz, Palmén, & García-Cuesta, 2012; Sáinz & Müller, 2018). A large body of work shows that a stereotype still exists that associates greater mathematical ability (compared to verbal expression and communication) to men over women (Hill, Corbett, & St. Rose, 2010; Gunderson et al., 2012; Sáinz & Müller, 2018). At the same time, the persistence of an important degree of gender segregation in the fields of study highlights the effect of gender-essentialist stereotypes that associate technical careers, such as engineering, with men and not with women (Charles & Bradley, 2009).

Where could these essentialist beliefs of the advisers originate? According to social role theory (Eagly, 1987; Eagly & Karau, 2002), it is not so much that the essential or natural differences between men and women explain the inequalities we see in the results (in power, in gender roles ...). On the contrary, the starting point is that there are inequalities that manifest themselves in the performance of different roles and, in an attempt to explain why these roles exist, we make essentialist attributions ('because men and women are different ... '). The basic principle of social role theory is that gender differences and similarities arise primarily from the distribution of men and women into social roles within society. That means that perceivers infer that there is a correspondence between the types of actions people engage in ('there are many men in engineering and technology activities') and their inner dispositions ('so men are better engineers and mathematicians'). Thus, gender stereotypes follow from the observation of people in typical social gender roles – especially, men's occupancy of the breadwinner and higher status roles, with perceivers attributing agentic traits to them, and women's occupancy of homemaker and lower status roles, with perceivers attributing communal traits to them.

In addition, these stereotypes, such as that regarding mathematics and language, can be explicit or implicit (Nosek et al., 2009; Smyth Frederick & Nosek, 2015). For instance, Smeding (2012) found that implicit gender-mathematics stereotypes – measured by an implicit association test – were weaker among female engineering students than female humanities students.

In the case of Spain, Sáinz et al. (2012) used a qualitative study to analyse how gender influences parents and teachers' perception of information and communication technology (ICT) professionals, and the influence of this on the decisions made by adolescents regarding study options. On the one hand, these advisers considered that gender does not condition adolescents' study choices, but on the other they held certain stereotypes regarding ICTs, some of them related to gender. For example, some teachers assumed that girls frequently had better grades in this area because they were more hard working and responsible than their male counterparts, whereas when discussing high achieving students, the highest intellectual capabilities were assigned to boys.

Double standards, status characteristics theory and the measurement of gender biases

Our procedure to detect possible gender biases in the recommendation to study engineering, and in the attribution of mathematical ability, can be understood in terms of the 'double standard' approach. A double standard is using different requirements to interpret the same evidence and, in particular, applying stricter requirements to members of devalued groups (Foschi, 2001).

Status characteristics theory (SCT) (Correll, Benard, & Paik, 2007; Correll & Ridgeway, 2003) directly addresses the double standard phenomenon. A status characteristic is a categorical distinction among people (for instance, depending on their gender) that has attached to it widely held beliefs in the culture that associate greater status worthiness and competence with one category of the distinction (men) than with the other (women). A status characteristic becomes salient when it differentiates those in the setting or because the characteristic is believed to be directly relevant to the task at hand ('men have a greater facility for mathematics'). The theory argues that actors then implicitly use the salient characteristic to guide their behaviour and evaluations. The result is biased evaluations, where a stricter standard is used when evaluating the lower status group, in our experiment the female target.

The SCT distinguishes between diffuse status cues (gender, age, race, etc.) and specific status cues (specific information about skills, abilities, etc.). Koch, D'Mello, and Sackett (2015) argue that stereotyping against women may be more important when there is little information available about the individual. In this case the decision maker tends to rely more on gender (a diffuse status cue) as the basis for decision. In our research, we present relatively little information to the participants about the target, so gender stereotypes are expected to become more influential.

Important experimental literature has been conducted to detect gender biases or double standards in the labour market (Fuegen, Biernat, & Haines, 2004; Correll et al., 2007; Hoover et al., 2018; Moss-Racusin, Dovidio, Brescollc, Graham, & Handelsman, 2012; Vandello, Hettinger, Bosson, & Siddiqi, 2013; Rudman & Mescher, 2013). For instance, in the laboratory experiment of Correll et al. (2007), participants evaluated application material for a pair of same-gender equally qualified job candidates who differed in their parental status. They found that mothers, compared with non-mothers, were penalized on a host of measures: perceived competence, recommended starting salary, etc. A similar result was obtained in the experimental research of Cuddy, Fiske, and Glick (2004). Likewise, in Vandello et al. (2013), based on an experimental design similar to that of Cuddy et al. (2004), participants evaluated hypothetical targets who sought a flexible work arrangement after the birth of a child. Flexibility seekers were given lower job evaluations than targets with traditional work arrangements (the flexibility stigma).

Following this line of experimental research, in this article, we intend to use a design that shares some aspects with Cuddy et al. (2004) and Vandello et al. (2013). However, in our research participants have to recommend to a greater or lesser extent a series of university degrees to each of the four targets (the four different profiles of a 15-year-old student). In other words, in the other studies the objective was to detect and quantify gender biases in the evaluation of the professional merits of the targets, while in our research we try to detect gender biases in the recommendation to study engineering, and also in the attribution of mathematical ability. Our experimental design is new both within the experimental literature, just mentioned, and in the literature on girls and women in STEM.

In our research, we also consider two levels of the target's academic record, intermediate and high, which allows us to highlight the "double standard" nature of the gender bias in the recommendation to study engineering. If we assume that there is a greater propensity for the participants to recommend engineering to a target with a high academic record than to one with an intermediate record, then, if there is a gender bias (against the female target) in the recommendation to study engineering, it should be possible to observe that the female target needs a high academic record to receive the same recommendation to study engineering as a male target with an intermediate record.

Mathematical ability as a mediating variable

The literature suggests that gender biases in the attribution of mathematical ability and in the recommendation to study technical careers – such as engineering – are not totally independent. For instance, UNESCO (2017, p. 47) affirms that 'in some contexts, parents have lower expectations of girls' ability in mathematics and place less value on girls' participation in science and mathematics' (see also Sáinz & Müller, 2018). However, no evidence to date has been obtained on this aspect regarding advisers' attitudes or behaviour. One of the objectives of our research is to provide some evidence of this.

As Figure 1 indicates, we propose that the total effect of the target's gender on the recommendation to study engineering can be divided into two effects: a direct effect (bottom of the figure) and an indirect effect (top of the figure). According to this second effect, the perception of the target's mathematical ability is a mediating variable. Indeed, we begin by assuming that the participants will attribute a greater degree of mathematical ability to the male target (than to the female target).

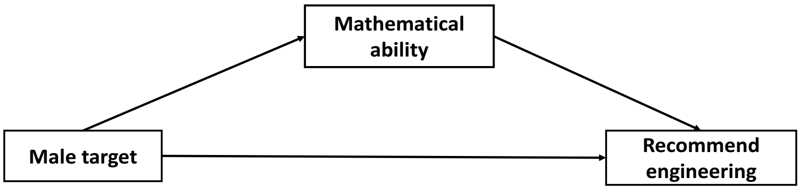

Figure 1. Mathematical Ability as a Mediating Variable.

Accordingly, a target who is attributed a higher mathematical ability will then be recommended to a greater degree to study careers such as engineering, which are high in mathematical content (Haase, Chen, Sheppard, Kolmos, & Mejlgaard, 2013). Regarding the latter, Sáinz and Eccles (2012, p. 487) maintain that 'mathematical abilities are considered a prerequisite for those students wanting to enroll in technological studies and those who want to gain admission to the related college majors and professional occupations'.

Hypotheses

Hypothesis 1. There is a gender bias in the recommendation to study engineering. Faced with an identical target, a fictitious 15-year-old student, the participants (on average) recommend studying engineering more to the male target than to the female target.

Hypothesis 2. There is a gender bias in the attribution of mathematical ability. Faced with an identical target, a fictitious 15-year-old student, the participants (on average) attribute a greater degree of mathematical ability to the male target than to the female target.

Hypothesis 3. The effect of the target's gender on the recommendation to study engineering is partially mediated by the attribution of mathematical ability. Being a male target has a direct positive effect on the participant's recommendation (to the target) to study engineering, but it also has an indirect positive effect through an attribution (to the target) of greater mathematical ability.

Method

Participants

Seven hundred and fifty-four university students from the Complutense University of Madrid and Technical University of Madrid, both located in the region of Madrid (Spain), participated in the experiment. Sampling was performed from February 2018 to May 2018. All the participants were studying bachelor or master's degrees (25.1% in the field of engineering, 33.8% in economics and business administration, 21.8% in health sciences, and 19.4% in humanities). 54.0% were female students and 46.0% were male students. 10.8% of the students were immigrants and 7% were foreign students. The average age of the participants was 21.6.

Design

A 2 × 2 factorial design was used. Factor 1 is the gender of the target (male, female) and factor 2 is the level of the academic record of the target (intermediate, high). Study participants were randomly assigned to each of these four experimental conditions. We also considered three variables concerning the characteristics of the participants: sex (female, male), age, and study area (engineering, economics and business administration, health sciences, and humanities).

Materials and variables

Questionnaire

Participants had to complete one questionnaire (in Spanish). It presented participants with a brief description of a fictitious 15-year-old student called María or Manuel (very common female and male names in Spain). The target was described as a 15-year-old student studying the last year of compulsory secondary education, in a 'colegio concertado' (private but public funded school). The description also included the academic record of the student for the current academic year. There were two levels of academic record (high, with an average grade of 8.95 on a scale of 0 to 10; and intermediate, with an average grade of 6.95). The structure of the grades, or relative grades (of the 11 subjects that appeared in the academic record) was kept constant across the two academic record levels. The detailed presentation of these academic records can be found in Appendix 1. There was also some gender-neutral information about the target's personality traits and tastes ('Manuel/María is a rather reflective, curious person; with an open mind about knowledge and new experiences. He/she likes music and movies. He/she plays tennis and paddle tennis').

At the top of the questionnaire, among other things, participants were told 'Please read the profile description of this student carefully. Imagine that you are one of his/her advisers and that this student has asked you for a (university degree choice) recommendation. What recommendation would you give him/her taking into account what you have read about his/her academic record, hobbies, etc. and your criteria about what you consider to be the most suitable university degrees for a student with these characteristics?'

After the description of the target, the questionnaire contained questions about career recommendations and the mathematical ability of the target. In addition, a set of demographic questions was added.

Recommend engineering

Participants rated 19 university degrees. They were asked "In the next 19 questions you are asked to indicate the extent to which you would advise Manuel/María to choose each of these degrees". The response scale ranged from 0 = "I would strongly advise against it" to 10 = "I would strongly advise it". These 19 degrees are listed in Appendix 2. In our analysis, we are only going to use these two items, Recommend Mechanical Engineering and Recommend Computer Engineering. We calculated the average of these two items and we obtained the two-item measure Recommend Engineering, ranging from 0 to 10 (Spearman correlation coefficient of the two items, $r_S(752) = .81$, $p < .001$; Cronbach's alpha = .90).

Mathematical ability

The participants were asked 'despite the little information you have, do you think that Manuel/María is equally qualified for mathematical reasoning and for verbal expression and communication?'. The response options were: 1 = "Manuel/María has much less talent for mathematics than for verbal expression and communication"; 2 = "… has less talent for mathematics than for verbal …"; 3 = "… has the same talent for mathematics as for verbal …"; 4 = "… has more talent for mathematics than for verbal …"; and 5 = "… has much more talent for mathematics than for verbal …". The single item variable Mathematical Ability (ranging from 1 to 5) is the second dependent variable in our study.

Factors and other variables

Regarding the target, there were two factors, Male Target, a dichotomous variable (1 = Manuel; 0 = María), and High Academic Record, a dichotomous variable (1 = high academic record; 0 = intermediate academic record). Regarding the participants, there was one variable, Female Participant, a dichotomous variable (1 = female participant; 0 = male participant). The participants' age and study area did not have any statistically significant effect on the results of our analysis, so these variables were excluded.

Procedure

The questionnaires were distributed in class to the students who decided to participate voluntarily in the experiment. The four experimental conditions were randomly assigned (male-high = 24.9% (n = 188); female-high = 25.7% (n = 194); male-intermediate = 24.0% (n = 181); female-intermediate = 25.3% (n = 191)). The questionnaires were administered at the beginning of the corresponding class, with the teacher's permission. Participants were recruited with a cover story that they were participating in a study within the field of education that explores the process by which adolescents choose the university career they are going to study. The average time to complete the questionnaire was 10 minutes. When providing instructions on how to fill out the questionnaire, among other things the researchers guided the participants saying "please, do not put what you would like to study, but what you would recommend to a young person with the characteristics that we are going to show you in the questionnaire".

The data collection was reviewed and approved by the 'ethics committee' (an institutional review board for compliance with standards for the ethical treatment of human participants) of the Faculty of Economics and Business of the Complutense University of Madrid.

Internal and external validity

We consider that the study has a high degree of internal validity, derived from the controlled experiment (2x2 factorial) conducted, which has allowed us to make a series of inferences regarding cause-effect relationships. Regarding its external validity, despite the fact that the participants are university students, we believe there are several reasons why this does not prevent our conclusions from being generalizable to other groups. First, university students are adults and educated human beings and, like the rest of the population, are depositaries of social norms and stereotypes (explicit or implicit) existing in their environment. Second, even university students can have real-life experience in advising others about what to study, for example, their younger siblings, cousins, partners, friends, etc. Third, in the experimental literature aimed at detecting gender biases (double standards) in the labour market (Correll et al., 2007; Cuddy et al., 2004; Hoover, Hack, García, Goodfriend, & Habashi, 2018; Vandello et al., 2013), the usual procedure is to use samples of university students. Given the characteristics of our participants (adults, young people, with a high cultural level and relatively socially privileged), we think that the biases detected also hold for other social groups, but, in terms of their intensity, our results may constitute the low end of what in reality exists.

Analytical strategy

In the results section, we used a three-way ANOVA analysis (for the dependent variables Recommend Engineering and Mathematical Ability) with SPSS (Arbuckle, 2017) to test hypotheses 1 and 2. The first two factors, Male Target and High Academic Record, are those corresponding to our 2 × 2 factorial design. The third factor considered is Female Participant, since this variable presented some interaction with one of the two other factors. In this way, a 2 (Male Target: Manuel or María) x 2 (High Academic Record: high or intermediate) x 2 (Female Participant: female or male) ANOVA was conducted (see Table 1).

In order to test hypothesis 3, we ran a path analysis through structural equation modelling (SEM). SEM allows us to analyse both complex path analysis models and mediation and/or moderation relationships.

Results

Gender bias in recommendations to study engineering

Hypothesis 1 stated that faced with an identical target (a fictitious 15-year-old student), the participants (on average) would recommend studying engineering more to the male target than to the female target.

As a preliminary result, Table A2 in Appendix 2 presents the average scores obtained for each of the 19 careers (recommendation scales) included in our design. This table shows that there is a clear gender pattern in the recommendation of careers to our target student. Technology-related careers were recommended to a greater extent to Manuel, while several careers stereotyped as feminine, such as primary education or fine arts, were more frequently recommended to María. This first result points to the confirmation of hypothesis 1.

As our three way ANOVA indicates (Table 1), the variable Male Target had a statistically significant effect on Recommend Engineering ($F(1, 745) = 48.82$, $p < .001$, $\eta p^2 = .06$). The mean scores for Recommend Engineering were 4.44 when the target was María and 5.87 when the target was Manuel (a Manuel-María ratio of 132.2%). This result brings to light that there was an important gender bias in favour of the male target in the recommendation to study engineering and confirms hypothesis 1.

No interaction was obtained between Male Target and the factors High Academic Record or Female Participant. Figure 2 shows that the participants recommended studying engineering to a greater degree to the target with a high academic record than to the one with an intermediate academic record: The line corresponding to the former is located above that of the latter. However, the bias in the recommendation to study engineering, captured by the positive slope of both lines, is similar for the two levels of academic record, as evidenced by the fact that the two lines are almost parallel. This figure serves to clearly illustrate the interpretation of the result obtained in terms of the

Table 1. Three-way ANOVA for Recommend Engineering and Mathematical Ability.

	Recommend Engineering				Mathematical Ability			
Significant Effects	*F*	*df*	*P*	ηp^2	*F*	*df*	*p*	ηp^2
Male Target	48.820	1, 745	<.001	0.062	8.189	1, 738	0.004	0.011
High Academic Record	67.564	1, 745	<.001	0.083	37.681	1, 738	<.001	0.049
Female Participant	9.303	1, 745	0.002	0.012	2.052	1, 738	0.152	0.003
Male Target x High Academic Record	0.351	1, 745	0.554	0.000	0.102	1, 738	0.750	0.000
Male Target x Female Participant	0.434	1, 745	0.510	0.001	5.516	1, 738	0.019	0.007

Note. Main effects and interactions with Male Target are shown.

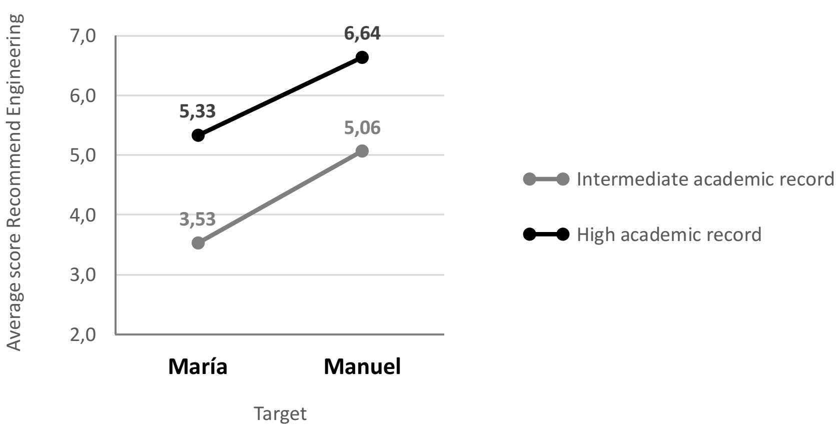

Figure 2. Differences in the Recommendation to Study Engineering (mean scores) According to Target' Gender and Target's Academic Record.

double standard phenomenon: when the male target had an intermediate academic record, the mean score for Recommend Engineering was 5.06, while the figure corresponding to the female target was very similar (5.33), but only when she had a high academic record.

Gender bias in the attribution of mathematical ability

Hypothesis 2 stated that faced with an identical target, a fictitious 15-year-old student, the participants (on average) would attribute a greater degree of mathematical ability to the male target (Manuel) than to the female target (María).

Table 1 also shows the results of the three-way ANOVA analysis for Mathematical Ability. The variable Male Target had a small but statistically significant effect on Mathematical Ability ($F(1, 738) = 8.19$, $p = .004$, $\eta p^2 = .01$). The mean scores in the attribution of mathematical ability were 2.90 when the target was María and 3.02 when the target was Manuel. This result shows that there was a gender bias in favour of the male target in the attribution of mathematical ability (relative to verbal expression and communication).

There was a statistically significant result in the interaction Male Target x Female Participant ($F(1, 738) = 5.52$, $p = .019$, $\eta p^2 = .01$). As Figure 3 shows, this result indicates that it is the male participants who present this bias, and not the female participants. Indeed, among the male participants, the mean scores in the attribution of mathematical ability were 2.87 when the target was María and 3.13 when the target was Manuel, which corresponds to a Manuel-María ratio of 108.9%. But among the female participants, the mean scores in the attribution of mathematical ability were practically the same for both targets.

Mathematical ability as a mediating variable

In this section, we tested the hypothesis 3 (mathematical ability is a mediating variable in the total effect of the target gender on the recommendation to study engineering). For this, we ran a path analysis, using structural equation modelling, for the dependent variable Recommend Engineering (Figure 4). This model had two main characteristics. First, it was a simple mediation model with one outcome variable (see Figure 1). Second, in view of the result obtained in the previous subsection, we introduced a moderating variable: we considered that the effect of Male Target on Mathematical Ability was moderated by Female Participant.

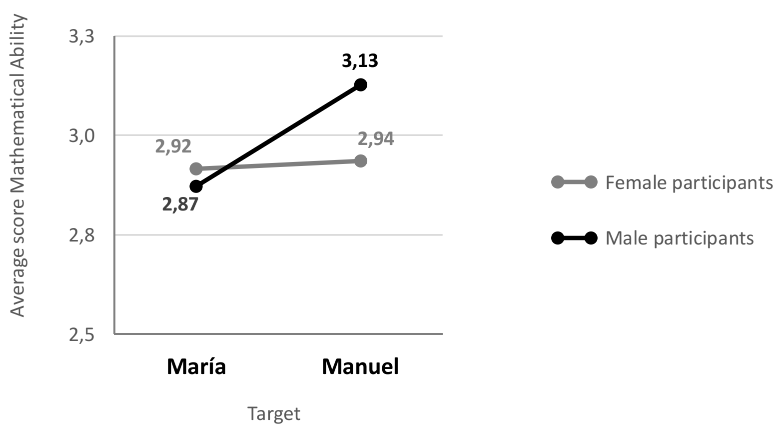

Figure 3. Differences in the Perception of Target's Mathematical Ability (mean scores) According to Target' Gender and Participant's Gender.

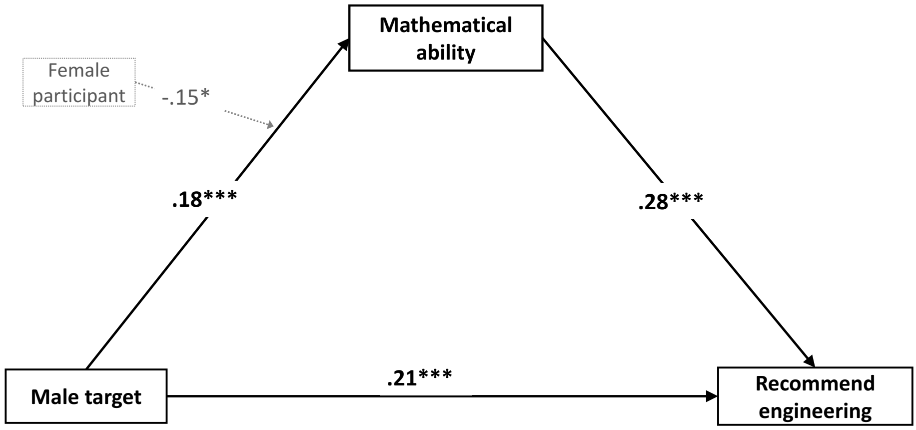

Figure 4. Mathematical Ability as a Mediating Variable. Path Analysis. *Note*. N = 754. Standardized regression weights are provided for each path. *p <.05. **p <.01. ***p <.001. Control variables: High Academic Record and Female Participant.

This path analysis was performed with the Amos 25.0 programme (Arbuckle, 2017). According to the fit indices commonly used in structural equation modelling (Arbuckle, 2017), the model presented an acceptable fit ($\chi 2$ (1) = 2.03, p = .155, *TLI* = .99, *RMSEA* = .04, *CFI* = 1.00 and *SRMR* = .01).

Male Target had a statistically significant positive direct effect (.21, p < .001) on Recommend Engineering. It also had a statistically significant positive indirect effect on Recommend Engineering through the mediating variable Mathematical Ability, but only for male participants. Indeed, for the subset of male participants, Male Target had a statistically significant positive effect (.18, p < .001) on Mathematical Ability; and Mathematical Ability had a statistically significant positive effect (.28, p < .001) on Recommend Engineering. The perception that the target had high mathematical ability had an important influence in the recommendation to study engineering.

Therefore, as Table A3 in Appendix 3 shows, when the participant was male, the conditional total effect of Male Target on Recommend Engineering was .26, which is obtained as the sum of the direct effect (.21) and the indirect effect (.05 = .18 × .28) of Male Target on Recommend Engineering. When the participant was female, the conditional total effect of Male Target on Recommend Engineering was .22, which is the sum of the direct effect (.21) and the indirect effect (.01 = .03 × .28).

In short, the path analysis performed in this section seems to support hypothesis 3: mathematical ability partially mediates in the total effect of the target gender on the recommendation to study engineering, but only for male participants.

Discussion

In the current study, we have offered causal empirical evidence about the existence of a gender bias in the recommendation to study engineering and in the attribution of mathematical ability. Presenting the same information about a 15-year-old target person with a female or male name activated the existing gender stereotypes concerning girls and technological STEM careers. This led, on average, to a biased recommendation to study engineering in favour of the target with a male name. For instance, when the male target had an intermediate academic record, the mean score for Recommend Engineering was 5.06, while the figure corresponding to the female target was very similar (5.33), but only when she had a high academic record. Expressed in terms of double standards: on average, the female target needs a higher academic record before she is recommended to study engineering with the same intensity as the male target. Furthermore, we have also shown that, in fact, the biased attribution of mathematical ability is one of the mechanisms (mediating variable) through which the target's male or female name influences the participants' recommendations to study engineering.

It is worth highlighting four additional aspects: first, in the context of the EVT, there is a substantial body of research (Eccles, 2014; Sáinz et al., 2012) about how parents, teachers, and counsellors transmit their beliefs and attitudes, and shape female and male adolescents' choice of course of study. However, the process through which existing stereotypes generate biased recommendations made by advisers has not been widely studied. Thus, we consider that our experimental analysis contributes to generating new knowledge and a new research line regarding one of the main elements included in the EVT framework.

Second, our instrument to detect the effect of the gender stereotypes on the recommendation to study engineering may have some aspects in common with the "Draw-A-Scientist" studies (Chambers, 1983; Miller, Nolla, Eagly, & Uttal, 2018). This approach, where children are asked to draw a scientist, aims to capture children's gender-science stereotypes linking science with men. In a similar way, our approach aims to capture participant's gender stereotypes linking engineering (technological STEMs) with men.

Third, the cognitive process (raised by the SCT) that activates existing gender stereotypes depending on whether the target has a female or male name may also have some aspects in common with Bem's theory of gender schema (Bem, 1981; Sáinz et al., 2012). According to this approach, gender schemas allow individuals, and to a greater extent "sex-typed" individuals, to take shortcuts in interpreting the information they receive and provide them with prescriptive information about what is considered appropriate for each gender (in the form of stereotypes).

Finally, in line with the fact that women, on average, tend to have slightly less traditional gender attitudes than men (Bolzendahl & Myers, 2004), our sample showed that the bias against the female target in the attribution of mathematical ability only occurred among male participants and not among female participants.

We consider that the present line of investigation has a high potential for future research. For instance, four extensions may interest researchers. First, the use of factorial survey experiments (Auspurg & Hinz, 2015). This methodology, which uses a wider set of multi-dimensional stimuli (vignettes), can considerably increase the number of experimental conditions included in the analysis and makes it possible to gain deeper insights into the judgements and decisions of the advisers. Second, the consideration of the explicit or implicit gender attitudes of the participants as a moderating variable. For instance, the effect of the target's gender on the recommendation to study engineering could be moderated by the implicit occupational gender stereotypes (White & White, 2006). Third, the possibility of repeating the analysis carried out in this article, but doing so for traditionally feminized fields of study, such as health sciences. Fourth, the use of some alternative measure of mathematical ability to that used in this article, so that mathematical ability is not expressed as an opposite to the ability for verbal expression and communication.

Our findings have practical implications for advisers and for public policy. A first step in neutralizing biases based on stereotypes is to be aware that we may be biased. This warning is particularly important for secondary school teachers, who accompany and guide adolescents in their career selection processes.

In this research, we have shown that gender biases in the recommendation to study engineering are still very strong. We think it is very important to generate supportive learning environments and conduct awareness campaigns in schools (for example, providing role models of female engineers), all aimed at encouraging girls to pursue mathematics, science and engineering (UNESCO, 2017). We believe that these campaigns should include parents, teachers and other counsellors, who should be alert to the persistence of the bias we have analysed here.

Finally, in order to level the playing field in STEM, it is necessary to level the playing field in unpaid work. A world in which it will seem absolutely normal for us to see women in the highest STEM positions will be a world in which it will seem absolutely normal for us to see (for example) men taking leave to care for their baby. Eliminating stereotypes in science and engineering means also eliminating stereotypes in the family.

Career choices for girls and boys is an important moment in their lives, and the influence of their advisers (parents, teachers, school counsellors, older siblings, etc.) can play a critical role. The present research contributes to the literature on girls' performance and interest in STEM fields by identifying a significant degree of gender bias in the advice of potential advisers. We provide experimental evidence that in Spain there is still an important bias against girls in the recommendations to study engineering.

We hope that the present research contributes to a better understanding of this type of bias as well as to the design of strategies to prevent it.

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Appendices

Appendix 1.

Table A1. Subjects and grades that appeared in the academic record included in the brief description of a fictitious 15-year-old student.

	Grades	
Subjects	High	Intermediate
Geography and History:	9	7
Spanish Language and Literature:	9	7
Mathematics:	9	7
English language	9	7
Physical education:	8	6
Ethical values:	10	8
Physics and chemistry:	9	7
Biology:	9	7
Economics:	9	7
Information and communication technologies:	9	7
Music:	8.5	6.5

(1) These 11 subjects are among those included in the official curricula of compulsory secondary education in Spain.
(2) The structure of the grades, or relative grades (of the 11 subjects that appear in the academic record) was kept constant across the two academic record levels. In this way, a distinction was made between the experimental condition "having a globally high academic record" and the experimental condition "having a globally intermediate academic record". However, we balanced maths and science scores with those of language and humanities, so that the target did not have a relatively more attractive academic record in any of these two areas.

Appendix 2.

Table A2. Means and Standard Deviations for Recommendations of Majors and Mathematical Ability by Target's Gender.

	Target						
	Female		Male		All		
	(*n* = 385)		(*n* = 369)		(*n* = 754)		Male-Female
	M	*SD*	*M*	*SD*	*M*	*SD*	Ratio
Recommend mechanical engineering	4.30	3.12	5.70	3.06	4.99	3.17	132.4%***
Recommend computer engineering	4.58	3.07	6.04	3.00	5.29	3.12	131.8%***
Recommend physics	5.01	2.89	5.83	2.70	5.41	2.82	116.4%***
Recommend chemistry	5.23	2.76	5.77	2.45	5.49	2.63	110.3%*
Recommend architecture	4.96	2.66	5.27	2.62	5.11	2.64	106.2%
Recommend economics	5.35	2.59	5.54	2.40	5.44	2.50	103.5%
Recommend business administration	5.08	2.86	5.21	2.73	5.14	2.80	102.7%
Recommend sport sciences	4.34	2.91	4.43	2.86	4.38	2.89	102.2%
Recommend medicine	6.25	2.90	6.31	2.80	6.28	2.85	101.0%
Recommend biology	5.86	2.62	5.86	2.26	5.86	2.45	100.0%
Recommend law	5.27	2.69	5.13	2.57	5.20	2.63	97.2%
Recommend history	4.60	2.83	4.42	2.78	4.51	2.81	96.0%
Recommend social work	5.60	3.12	5.34	3.08	5.47	3.10	95.3%
Recommend pharmacy	5.82	2.75	5.54	2.56	5.68	2.66	95.2%
Recommend psychology	7.14	2.22	6.69	2.44	6.92	2.34	93.6%*
Recommend journalism	6.50	2.74	6.02	2.88	6.26	2.82	92.7%*
Recommend philology	4.91	3.00	4.48	2.90	4.70	2.96	91.1%*
Recommend primary education	5.48	2.85	4.88	2.97	5.19	2.92	89.0%**
Recommend fine arts	5.09	3.05	4.49	3.11	4.80	3.09	88.3%**
Mathematical Ability	2.90	0.65	3.02	0.69	2.96	0.67	104.4%**

Mann–Whitney U test for differences in the distributions of female and male target.
*p <.05. **p <.01. ***p <.001.

Appendix 3.

Table A3. Direct, conditional indirect, and conditional total effects of Male Target on Recommend Engineering.

Direct effect of Male Target on Recommend Engineering			
	Effect	Boot LL 95% CI	Boot UL 95% CI
	.21	.15	.28
Conditional indirect effects of Male Target on Recommend Engineering			
Mediator	Mathematical Ability		
Moderators			
Participant's Gender	Effect	Boot LL 95% CI	Boot UL 95% CI
Female	.01	−.01	.03
Male	.05	.02	.08
Conditional total effects of Male Target on Recommend Engineering			
Mediator	Mathematical Ability		
Moderators			
Participant's Gender	Effect	Boot LL 95% CI	Boot UL 95% CI
Female	.22	.16	.29
Male	.26	.20	.33

Standardized coefficients.
Bootstrap sample = 5000 for percentile bootstrap confidence intervals.