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ORIGINAL ARTICLE

The Stereotypical Computer Scientist: Gendered Media Representations as a Barrier to Inclusion for Women

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Abstract The present research examines undergraduates' stereotypes of the people in computer science, and whether changing these stereotypes using the media can influence women's interest in computer science. In Study 1, college students at two U.S. West Coast universities (N=293) provided descriptions of computer science majors. Coding these descriptions revealed that computer scientists were perceived as having traits that are incompatible with the female gender role, such as lacking interpersonal skills and being singularly focused on computers. In Study 2, college students at two U.S. West Coast universities (N=54) read fabricated newspaper articles about computer scientists that either described them as fitting the current stereotypes or no longer fitting these stereotypes. Women who read that computer scientists no longer fit the stereotypes expressed more interest in computer science than those who read that computer scientists fit the stereotypes. In contrast, men's interest in computer science did not differ across articles. Taken together, these studies suggest that stereotypes of academic fields influence who chooses to participate in these fields, and that recruiting efforts to draw more women into computer science would benefit from media efforts that alter how computer scientists are depicted.

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> *"Oh, my gosh, [computer science] isn't for me… I don't dream in code like they do."*- Female student at Carnegie Mellon University (Margolis and Fisher 2002, p. 69)

Introduction

The quote above illustrates how stereotypes about the people in a field can powerfully influence academic decisions. This student may have the potential to become a successful computer scientist, but her stereotypes about computer scientists—that they "dream in code"—cause her to question whether she belongs in the field. In the current work, we focus on the field of computer science, a field that occupies a position of increasing importance in the U.S. in terms of job growth and salary (Bureau of Labor Statistics 2005) and in shaping the future. Despite the prestige and impact of this field, women remain highly underrepresented in computer science (National Science Foundation 2009). Across all age groups in the U.S. (Dryburgh 2000; Hess and Miura 1985) and in many other countries (Charles and Bradley 2006), women consider a future in computer science to a lesser extent than men. Gender disparities in computer science result not only in missed opportunities for women to participate in a lucrative and influential field, but society may be deprived of the benefits that diverse perspectives can offer (Hong and Page 2004; Margolis and Fisher 2002; Plaut et al. in press).

We argue that one significant factor in this underrepresentation is students' stereotypes of computer scientists. More specifically, the gendered nature of these stereotypes

in the U.S.—the predominately masculine characteristics conjured by stereotypical images of computer scientists—may deter women from becoming interested in the field. We further suggest that media sources (e.g., newspaper articles) can be a vehicle through which stereotypes of academic fields are communicated, perpetuated, and transformed. Accordingly, we conduct two studies to examine students' stereotypes of computer scientists and the effects of changing these stereotypes using the media on women's interest in computer science. In the first study, we code students' descriptions of computer science majors to assess their stereotypes. In the second study, we examine the effects of exposure to these stereotypes versus a less stereotypical image of computer science on female and male students' interest in computer science.

Stereotypes of Science Fields

Academic fields, like all social groups, possess stereotypes, or mental representations of the group's characteristics (Allport 1954; Katz and Braly 1933; Lippman 1922; Oakes et al. 1994). In their now classic study on perceptions of scientists, Mead and Métraux (1957) asked 35,000 U.S. high school students to write an essay describing their image of a scientist. The dominant image that emerged was a middle-aged male who wore glasses and a lab coat and worked alone running experiments. More recent studies have found that U.S. high school and middle school students' perceptions of scientists are largely the same today (see Finson 2002 for a review; Fort and Varney 1989; Knight and Cunningham 2004; Mercier et al. 2006). Although stereotypes of scientists are exaggerated and inaccurate (Borg 1999; Clarke and Teague 1996; Pion and Lipsey 1981), they persevere as the dominant representation of the people who work in these fields. Endorsement of scientist stereotypes occurs across ages, genders, and racial groups in the U.S. (Barman 1999; Finson 2003; Fort and Varney 1989; Schibeci and Sorensen 1983), and has also been documented internationally (Buldu 2006; Chambers 1983; Newton and Newton 1988).

In the current work, we investigate U.S. undergraduates' stereotypes of computer science students and gender differences in the endorsement and implications of these stereotypes. We focus specifically on computer science students instead of a broader category of scientists for several reasons. First, in contrast to fields like biology and chemistry, women in the U.S. are still significantly less likely than men to receive undergraduate degrees in computer science, and these gender disparities are increasing rather than decreasing (National Science Foundation 2009). Second, although there may be overlap between stereotypes of computer scientists and stereotypes of scientists more broadly, previous work suggests that computer scientists may compel particular stereotypes (Kendall 1999; Margolis and Fisher 2002) that are especially problematic for women because of their association with males (Cheryan et al. 2009; Diekman et al. 2011). Below we review the literature describing prominent stereotypes of computer scientists among students. All cited studies use U.S. samples, unless otherwise noted. We highlight the potential of these stereotypes to alienate women who might otherwise be interested in the field and further consider whether there may be gender differences in perceptions of computer scientists. While some computer science stereotypes may be representative of a majority of members and critical to membership (e.g., knowing about technology), others may be more peripheral and less accurate (e.g., liking science fiction).

Technology-Oriented

The first stereotype involves a perception that computer scientists are technology-oriented, with strong interests in programming and electronics (Cheryan et al. 2011b; Schott and Selwyn 2000; Singh et al. 2007) and little interest in people (Diekman et al. 2010; Lippa 1998; Schott and Selwyn 2000). For instance, undergraduates stereotype computer scientists as highly-skilled computer programmers who enjoy tinkering with electronics (Margolis and Fisher 2002). At the same time, undergraduates also perceive that computer scientists are less likely to work with and help others compared to those in other careers, such as medicine and law (Clarke and Teague 1996; Diekman et al. 2010; Morgan et al. 2001). These stereotypes appear to be held by both male and female students (Singh et al. 2007) and are also documented in the U.K. (Schott and Selwyn 2000) and Australia (Lang 2007; Lang et al. 2010), suggesting that this work may be relevant internationally as well. The perception that computer science is technology-oriented rather than people-oriented may cause women to express less interest in the field than men (Diekman et al. 2010).

Singularly Focused on Computers

A second stereotype is that computer scientists are so focused on technology that they are obsessed with computers and programming, to the exclusion of other interests (Beyer et al. 2003; Margolis and Fisher 2002). Claims that computer scientists were "born coding" or "dream in code" reflect this presumed singular focus. Computer scientists are stereotyped by both male and female undergraduates as having an "obsession with machines" (Beyer et al. 2003, p. 52) and being "myopically focused [on computers]…to the neglect of all else" (Margolis and Fisher 2002, p. 65). Likewise, high school students in the U.K. perceived computer scientists as "fanatical" with an "addiction" to technology (Schott and Selwyn 2000, p. 292). Such focus goes beyond simply

having a proclivity toward technology or being hardworking, and instead involves having a singular mindset that renders other domains less important. The stereotype that computer scientists are singularly focused on computers and programming may deter women to a greater extent than it does men.

Lacking Interpersonal Skills

Another stereotype of computer scientists is that they lack interpersonal skills and are socially awkward (Beyer et al. 2003; Mercier et al. 2006; Schott and Selwyn 2000). This stereotype has been endorsed by undergraduates (Beyer et al. 2003; Margolis and Fisher 2002) and by high school students in the U.K. (Schott and Selwyn 2000), and even middle school students are aware of this stereotype (Mercier et al. 2006). Stereotypes that computer scientists lack interpersonal skills can be contrasted with expectations that women are socially competent and people-oriented (Diekman et al. 2010; Eagly and Steffen 1984). Interestingly, some evidence suggests that male undergraduates are more likely to endorse the stereotype of computer scientists as "loners" than are female undergraduates (Beyer et al. 2003), although women may be deterred by this stereotype more so than men (Diekman et al. 2010).

Intelligent

Computer scientists, and scientists more generally, are stereotyped as "intelligent" (Beyer et al. 2003, p. 49), "geniuses" (Schott and Selwyn 2000, p. 298), and "logical" (Schott and Selwyn 2000, p. 292). The pervasive stereotype of computer scientists as being nerds or geeks further conveys the notion that they are smart (Beyer et al. 2003; Margolis and Fisher 2002; Schott and Selwyn 2000). This connection between computer science and "nerdiness" is portrayed prevalently in U.S. media (Kendall 1999; Mercier et al. 2006; Schott and Selwyn 2000) and is endorsed by male and female undergraduates (Margolis and Fisher 2002) and by high school students in the U.K. (Schott and Selwyn 2000). Both male and female students perceive males in computer science as having a higher GPA than females in the field, even when no real differences exist (Beyer 1999), and women have less confidence in their computer aptitude than do men (Beyer et al. 2003). As a result, some women, even those qualified to enter the field, may assume they are not intellectually equal to those already in computer science and may be reluctant to enter the field.

Physical Features

When students conjure up an image of a computer scientist, they tend to imagine a male who is unattractive, pale and thin, and wearing glasses (Mercier et al. 2006). For example, drawings of computer users by middle school students have included glasses, pale skin, and abnormal body weight (Mercier et al. 2006). These physical features are also associated with scientists more generally (Barman 1999; Chambers 1983). Though males in 6th grade used a greater number of stereotypical characteristics in their portrayal of the computer users, among 8th graders these gender differences did not emerge, with male and female students using the same number of stereotypical characteristics in their drawings. Stereotypes of computer scientists' physical appearance may deter women more than men due to the fact that maintaining an attractive appearance is a component of the female gender role (Cejka and Eagly 1999).

Masculine

Female and male college students perceive that the majority of computer scientists are male (Beyer et al. 2003; Cheryan and Plaut 2010; Schott and Selwyn 2000). Similarly, when elementary school children are asked to draw a scientist or a computer user, they overwhelmingly depict male scientists and computer users (Barman 1999; Chambers 1983; Flick 1990; Knight and Cunningham 2004; Mercier et al. 2006). A study with over a half a million people from 34 countries revealed that approximately 70 % of participants implicitly associated science with males more than with females, with both males and females showing this implicit association (Nosek et al. 2009). Furthermore, computer scientists are also stereotyped by undergraduates as having interests such as liking science fiction and playing video games (Cheryan et al. 2009; Cheryan et al. 2011b; Kendall 1999), hobbies that are more associated with males than females (e.g., Cherney and London 2006). The stereotype that computer scientists are males who have masculine interests may lead some women to question whether they belong in computer science.

Taken together, the image of a computer scientist that emerges in the U.S. is one of a genius male computer hacker who spends a great deal of time alone on the computer, has an inadequate social life, and enjoys hobbies involving science fiction. Similar to stereotypes of other social groups (e.g., Deaux and Lewis 1984), stereotypes of computer scientists appear to span multiple components, including traits, behaviors, and physical appearance. Interestingly, middle school and high school students are more likely to use stereotypical characteristics when describing scientists (e.g., male wearing a lab coat and glasses) than younger students (i.e., pre-second grade; Barman 1999; Chambers 1983), suggesting that these stereotypes are learned and accepted during the later years of elementary school. These stereotypes are generally endorsed equally by both men and women (see Beyer et al. 2003 for an exception).

While much of the work on computer science stereotypes has either investigated undergraduates who are already

pursuing computer science (Beyer et al. 2003; Margolis and Fisher 2002) or examined stereotypes among younger populations (Mercier et al. 2006; Schott and Selwyn 2000), we ask college undergraduates who are not yet in computer science for their perceptions of their peers in computer science. Understanding what prevents women who are not yet in the field from entering computer science is crucial to achieving gender parity in science, technology, engineering, and mathematics (STEM) fields (Ceci et al. 2009; de Cohen and Deterding 2009). Stereotypes may be particularly prominent among those who are not in the field (Park and Judd 1990). Indeed, past work using a U.K. sample suggests that stereotypes about computer scientists' lack of sociability may be more prevalent among students with less computing experience (Schott and Selwyn 2000). The present work thus investigates whether female and male undergraduates spontaneously generate a stereotypical image when asked to describe computer science majors and the potential consequences of holding such stereotypes on their interest in entering computer science. Though both female and male students may be aware of the stereotypes, we suggest that negative effects of the stereotypes will be more pronounced among females than males.

Effects of Academic Stereotypes on Women's Interest

When choosing a major, undergraduates not only consider required classes and career prospects, but they also compare themselves to those currently in the field for clues about whether they belong and would be successful there (Creamer et al. 2007; Hannover and Kessels 2004; Walton and Cohen 2007). As a result, altering the way people in a field are depicted influences who expresses interest in that field. For instance, undergraduate women who were exposed to a computer science classroom containing objects stereotypically associated with computer science (e.g., video games, *Star Trek* posters) inferred that they would not belong there and expressed less interest in taking computer science courses than women who were exposed to a classroom that did not fit these stereotypes (Cheryan et al. 2011a; Cheryan et al. 2009). In addition, interacting with a peer who fits computer science stereotypes (e.g., wears glasses and a t-shirt that says "I code therefore I am") reduced women's anticipated performance in computer science but did not similarly affect men's anticipated performance (Cheryan et al. 2011b). Because the female gender role influences the way women see themselves (Eagly 1987), the perceived incompatibility between computer science stereotypes and the female gender role compromised women's sense of belonging and discouraged them from pursuing these fields (Cheryan et al. 2009; Diekman et al. 2010).

In the previous work mentioned above, computer science stereotypes were made salient by exposing students to a specific example of a person or an environment. In the current work, we set out to discover what the stereotypical computer scientist looks like in students' minds without compelling a particular representation. We then directly manipulate this image—using fabricated newspaper articles—to examine its influence on women's interest in entering the field.

The Role of the Media in Transmitting and Changing Stereotypes

The way a social group is represented in the media—including broadcast media (e.g., television, film), internet media (e.g., blogs), and print media (e.g., newspapers)—influences how people think about that group and their relation to it (Davies et al. 2002; Fryberg et al. 2008; Pronin et al. 2004). For example, undergraduate women who watched gender-stereotypic commercials in which women excessively focused on their appearance subsequently exhibited less interest in technical careers than those who were not exposed to these commercials (Davies et al. 2002). In another example, undergraduate women who were exposed to biographies of female engineers had more positive implicit attitudes toward math compared to women who saw biographies of male engineers (Stout et al. 2011). These findings suggest that subtle manipulations in the messages communicated by the media can both deter and promote women's interest in STEM fields.

Unfortunately, the people in STEM careers are often depicted in a highly stereotypical manner (Kendall 1999; Schibeci 1986; see also Steinke 2005). Movies such as *Revenge of the Nerds*, *Weird Science*, and *WarGames* promoted the image of the "computer nerd" during the 1980s (Barker and Aspray 2006; Schott and Selwyn 2000), coinciding with the beginning of the decline in the proportion of women pursuing computer science in the U.S. (National Science Foundation 2002). More recently, CBS's popular television show *The Big Bang Theory* (http://www.cbs.com/primetime/big_bang_theory), currently in its sixth season, profiles graduate students in physics and engineering who look and act in ways consistent with computer science stereotypes. These media representations are especially troubling considering that children report that television, movies, and magazines constitute their primary source of information about what scientists are like (Fort and Varney 1989; Steinke et al. 2007). Such media depictions may cause students to believe that these characteristics are not only typical but even required of people in the field. As a result, students who do not fit the current stereotypes may be discouraged from developing an interest in these fields.

Several campaigns are currently underway that use the media to attempt to change stereotypes of computer scientists and draw more women into the field. For example, the

PBS television series *SciGirls* (http://pbskids.org/scigirls/) is an educational program that inspires young girls' interests in STEM by showing how science and technology can be used creatively to help solve problems in everyday life. The Dot Diva (http://dotdiva.org) and Picture Me in Computing (http://picturemeincomputing.com/) campaigns are both trying to broaden the image of computer science through internet media by unveiling to girls a new image of computer science that is more compatible with the female gender role (see also Linde 2011). News articles that highlight changes in the image of computer scientists, such as a 2012 *USA Today* article stating that "the stereotype of the geeky techie that persists in pop culture is fading in real life" (El Nasser 2012, para 2), may help to disseminate a broader image of computer scientists. Media sources have the potential to reach a large and varied audience. At the same time, people may be prone to believing some media messages more than others (Kiousis 2001). Understanding how students respond to media messages about computer scientists could help efforts to diversify computer science and other fields.

Study 1: Perceptions of Computer Scientists

In one of the first studies asking students to report their perceptions of a field, Mead and Métraux (1957) had high school students write an essay describing science and their image of a scientist. In the present study, we used a similar methodology to understand how college students perceive computer scientists by asking students to describe computer science majors. We then coded their answers to assess the content and pervasiveness of the representations generated. Like Mead and Métraux (1957), we intentionally did not ask about stereotypes per se but instead instructed students to give us their descriptions of computer science majors. We chose to use a sample of college students who were not already invested in computer science to focus on perceptions of those who had the potential to be recruited into the field. We hypothesized that the representation generated of a computer science major will be that of a male "computer nerd" – one who is technology-oriented, highly intelligent, lacks interpersonal skills, has specific physical features (e.g., wears glasses), and has masculine interests. We further investigated whether gender differences will emerge in the stereotypes generated. Although both female and male students may hold similar stereotypes about computer scientists, males may be more likely than females to hold some stereotypes about computer scientists (i.e., lacking interpersonal skills) (Beyer et al. 2003). Finally, we hypothesized that female and male students with less background in computer science will endorse these stereotypes more than those with more background in computer science. We tested this last hypothesis by regressing whether participants mentioned a computer science stereotype on gender, whether or not they have taken a computer science class in college, and their interaction.

Method

Participants

Three-hundred eighteen students at Stanford University and the University of Washington (UW) were recruited. One participant who left the description blank and 23 participants who did not specify gender were eliminated from analyses. One participant over the age of 30 was also eliminated to focus on younger undergraduates. The final sample thus consisted of 293 participants. The majority of participants (n=193) completed the questionnaire on paper as part of a mass testing session through the psychology subject pool for course credit at Stanford University, while the rest (n=100) completed the questionnaire online through the psychology subject pool for course credit at UW. See Table 1 for a breakdown of demographic information split by gender and school.

Materials and Procedure

Participants were given a questionnaire that asked them to "describe computer science majors" (Stanford participants) or "describe what computer science majors are like" (UW participants). Two researchers (one female, one male) coded responses for the mention of several stereotypical categories that were generated based on a review of the literature mentioned in the introduction. Coders were provided a codebook that defined each category (see Table 2) and were blind to all other information about the participants. Categories included intelligent, technology-oriented, singularly focused on computers, lacking interpersonal skills, masculine, and possessing certain physical features (i.e., pale, glasses, thin, unattractive). Coders also coded for two counterstereotypical categories: feminine and people-oriented. Because very few females (only one at each school) and no males mentioned either of the counterstereotypical categories in their responses, we do not include these categories in our analyses. For each category, responses were coded as either being present or not. Each category was evaluated separately from the other categories for each participant, meaning that one description could fall into more than one category. Discrepancies were resolved through discussions (see Table 2 for reliability statistics for each category). Whether or not participants had taken a college computer science course was assessed by asking whether they had taken a computer science class in college (Stanford participants) or the number of computer science classes taken in college (UW participants; recoded as none

Table 1 Demographic information of participants in Study 1 by gender and school

		Females (n=168)		Males (n=125)	
		Stanford (n=115)	UW (n=53)	Stanford (n=78)	UW (n=47)
Age	M (SD)	18.97 (1.33)	19.21 (1.38)	19.18 (1.48)	19.06 (0.97)
Race	White	42 (36.5 %)	15 (28.3 %)	33 (42.3 %)	18 (38.3 %)
	Asian American	29 (25.2 %)	34 (64.2 %)	22 (28.2 %)	20 (42.6 %)
	Latino	12 (10.4 %)	0	5 (6.4 %)	3 (6.4 %)
	African American	8 (7.0 %)	0	2 (2.6 %)	2 (4.3 %)
	Multiracial	21 (18.3 %)	4 (7.5 %)	13 (16.7 %)	4 (8.5 %)
	Other/unidentified	3 (2.6 %)	0	3 (3.8 %)	0
Year	Freshman	40 (34.8 %)	27 (50.9 %)	29 (37.2 %)	20 (42.6 %)
	Sophomore	28 (24.3 %)	16 (30.2 %)	27 (34.6 %)	20 (42.6 %)
	Junior	18 (15.7 %)	9 (17.0 %)	8 (10.3 %)	3 (6.4 %)
	Senior	14 (12.2 %)	0	4 (5.1 %)	4 (8.5 %)
	Other	3 (2.6 %)	1 (1.9 %)	3 (3.8 %)	0
	Not Provided	12 (10.4 %)	0	7 (9.0 %)	0
Major	Biology		7 (13.2 %)		8 (17.0 %)
	Business		5 (9.5 %)		6 (12.8 %)
	Psychology		6 (11.4 %)		4 (8.4 %)
	Other		35 (65.9 %)		29 (61.8 %)

Percentages calculated within gender and school. Information on participants' majors was available for the UW sample but not the Stanford sample

or at least one). Participants also provided demographic information at the end, including race and gender.

Results

Frequency of Mentioning Stereotypes

Consistent with our hypothesis, the majority of female and male participants mentioned at least one stereotype of computer scientists in their responses (see Table 3 for percentages of how often a stereotype was mentioned). The most commonly mentioned categories by both women and men when describing computer science majors were intelligent and technology-oriented, and singularly focused on computers and lacking interpersonal skills were the next most common. Less than a third of participants (24.3 % of Stanford females, 7.5 % of UW females, 30.8 % of Stanford males, 6.4 % of UW males) described computer science majors without invoking any of the categories (e.g., "it takes a certain type of person"). About half of the responses (52.2 % of Stanford females, 47.2 % of UW females, 44.9 % of Stanford males, 44.7 % of UW males) mentioned one category (e.g., "socially awkward, inactive"). The remaining participants (23.5 % of Stanford females, 45.3 % of UW females, 24.4 % of Stanford males, 48.9 % of UW males) mentioned two or more categories (e.g., "they are generally introverted, intelligent, off-beat, and tend to lack social skills").

Table 2 Sample responses of participants describing computer science majors and coder reliabilities (kappa, percent agree) for analyses of students' descriptions of computer science majors in Study 1

Category	Description	Sample responses	Kappa	% Agree
Intelligent	Smart or "nerdy"	"Very, very smart…"	.911	95.6
Technology-oriented	Skills or interest in technology, works alone	"…enjoy working with computers…"	.847	93.2
Singularly focused on computers	Very focused or intense	"Very focused…obsessed with computers"	.619	90.4
Lacks interpersonal skills	Socially awkward, few social interactions	"…no social life"	.774	94.5
Masculine	Males, masculine interests (e.g., videogames)	"…they play WOW all day long"	.893	98.6
Physical traits	Glasses, pale, thin, unattractive	"…I picture them wearing glasses"	.891	99.0

Table 3 Students' descriptions of computer science majors in Study 1

Category	Count of Participants Mentioning Category (% by Gender and School)					
	Females (n=168)		Males (n=125)		χ^2	
	Stanford (n=115)	UW (n=53)	Stanford (n=78)	UW (n=47)	Stanford df=1	UW df=1
Intelligent	55 (47.8)	36 (67.9)	32 (41.0)	28 (59.6)	<1	<1
Technology-oriented	26 (22.6)	26 (49.1)	17 (21.8)	24 (51.1)	<1	<1
Singularly focused on computers	17 (14.8)	3 (5.7)	19 (24.4)	7 (14.9)	2.81†	N/A
Lacks interpersonal skills	15 (13.0)	7 (13.2)	10 (12.8)	8 (17.0)	<1	<1
Masculine	5 (4.3)	7 (13.2)	1 (1.3)	7 (14.9)	N/A	<1
Physical traits	6 (5.2)	5 (9.4)	3 (3.8)	1 (2.1)	N/A	N/A
Any category	87 (75.7)	49 (92.5)	54 (69.2)	44 (93.6)	<1	<1

† p<.10. Chi-square values were computed for each category by comparing the percentage of responses generated by males and females at each school. A chi-square value could not be computed for some categories because of the low numbers of at least one gender mentioning this category

Gender Differences in Likelihood of Mentioning a Stereotype

Women and men did not differ in their likelihood of mentioning one or more categories (see Table 3). Looking at the categories individually also revealed no differences in the likelihood of mentioning any category when describing computer science majors except that Stanford men were marginally more likely than Stanford women to mention that computer science majors are singularly focused on computers. Note that we did not conduct a formal chi-squared test of the physical features category (UW and Stanford), the singularly focused category (UW), or the masculine category (Stanford) because of the low number of at least one gender who mentioned these categories. However, Fisher's exact tests revealed no differences between women and men in their likelihood of mentioning these categories when describing computer scientists: physical features (Stanford): p=.74, physical features (UW): p=.21; singularly focused (UW): p=.18; masculine (Stanford): p=.40.

Influence of Experience in Computer Science on use of Stereotypes

In order to test our hypothesis that female and male students with experience in computer science will be less likely to produce stereotypical images of computer scientists, we ran a regression on the Stanford participants. (We did not include a similar UW analysis because only four women reported taking at least one college computer science course.) We included gender (0=male, 1=female), having taken at least one college computer science class (0=no class, 1=more than one class), and their interaction as explanatory variables and mentioning a stereotypical category as the outcome variable. A marginal effect of gender emerged, qualified by a significant interaction (see Table 4). Variance inflation factors were less than 3 for each predictor and no standard error in the logistic regression was larger than 1, suggesting no evidence of multicollinearity. To decompose the interaction, we split the data by gender and regressed the likelihood of mentioning stereotypes on previous experience. Previous experience predicted mentioning stereotypes for women (B=−1.36, SE=.57, Wald χ^2=5.68, p=.02) but not for men (B=.49, SE=.64, Wald χ^2=.57, p=.45). Conducting separate chi-square analyses for women and men yielded the same results: Women who had not taken a computer science class were significantly more likely to mention one of the stereotypical categories in describing computer scientists (89.2 %) than women who had taken at least one computer science class (68.0 %), χ^2(df=1, N=99)=6.19, p=.01. There was no similar effect of computer science classes on men's likelihood of describing computer scientists in a stereotypical manner (72.3 % with no previous experience and 81.0 % with experience), χ^2(df=1, N=68)<1, *ns*.

Discussion

A distinct image of computer science majors emerged from responses to an open-ended question asking undergraduates to describe them. Both women and men spontaneously

Table 4 Summary of logistic regression analysis predicting mention of stereotype among Stanford sample in Study 1

Variable	B	df	SE	Wald	e^B
College CS	.49	1	.64	.57	1.63
Gender	1.15*	1	.50	5.35	3.15
College CS×Gender	−1.84*	1	.86	4.59	.16
Constant	.96**	1	.33	8.69	2.62

* p<.05; ** p<.01. College CS = having taken at least one college computer science class. Model χ^2 (df=3)=8.10, p<.05

offered an image of computer scientists as technology-oriented, intensely focused on computers, intelligent, and socially unskilled. These characteristics contrast with the female gender role, which commonly prescribes being people-oriented and concerned with appearance (Cejka and Eagly 1999; Diekman et al. 2010; Eagly and Steffen 1984). Interestingly, only a small minority of students spontaneously described computer science majors as male or masculine, despite previous evidence that undergraduates are aware that computer science is a male-dominated field (Cheryan and Plaut 2010). One possibility is that the association with males is more likely to emerge when asked directly about it (Cheryan and Plaut 2010) or when drawing an image of computer scientists (Mercier et al. 2006), rather than when asked to write a description. Additionally, the type of masculinity represented by computer science stereotypes (e.g., playing videogames) may be perceived as distinct from more traditional notions of masculinity (e.g., being athletic) (Kendall 1999). However, computer science stereotypes are nevertheless perceived as incompatible with the female gender role and inconsistent with the way that many women see themselves (Cheryan et al. 2009).

In line with most previous work (Mercier et al. 2006; Schott and Selwyn 2000), women and men largely did not differ in how they described computer scientists, which may result from the widespread circulation of computer science stereotypes in society (Kendall 1999). Although there were no gender differences in endorsement of most of the stereotypes, at Stanford, men were more likely than women to stereotype computer scientists as singularly focused on computers. This result is consistent with Beyer et al.'s (2003) finding that men were more likely than women to believe computer scientists were loners.

Study 1 revealed that women who had not taken a computer science class were more likely to generate stereotypical images than women who had, suggesting that a key source of these stereotypes may lie outside these classes. Encouraging women to take computer science classes may provide them a more accurate image of what computer science majors are like. In the following study, we investigate whether the media—an important source of information outside the classroom—can change these stereotypes and draw more women into computer science.

Study 2: Manipulating Computer Science Stereotypes Using the Media

To examine effects of changing stereotypes of computer scientists using the media, we used an article prime paradigm (e.g., Plaut et al. 2011; Williams and Eberhardt 2008) in which we manipulated the depiction of computer science majors in a manner that was consistent or inconsistent with the stereotypes found in Study 1. Women's preferences for male-dominated careers can be influenced by the extent to which they are framed as compatible with the female gender role (Diekman et al. 2011) and the present study extends these results by showing how the media can be used to change stereotypes and draw more women into male-dominated fields.

Participants read one of two fabricated newspaper articles stating either that computer science majors fit current stereotypes or that the field is changing to be less consistent with these stereotypes. We analyzed the effect of this media manipulation on undergraduates' interest in majoring in computer science and compared these results with baseline data from participants who did not read an article. We hypothesized that female students who read a news article stating that computer scientists fit the current stereotypes will express less interest in computer science than female students who read an article stating that computer scientists no longer fit the stereotypes. We predicted that the news articles will have no effect on men's interest. Because of the widespread endorsement of computer science stereotypes (as evidenced in Study 1), we further hypothesized that for female students, reading the stereotypical article will have a comparable effect on interest as reading no article, but that the alternate representation offered in the non-stereotypical article will increase interest above these two conditions.

Method

Participants

Sixty students (32 women, 27 men, one participant who did not identify gender was omitted) were recruited as part of a mass testing session through Stanford University's psychology subject pool or by individually approaching students in public locations on the UW campus (e.g., dining hall, library café) and asking them to participate. Five other participants were excluded from analyses: three who were not undergraduates and two who incorrectly summarized the article, leaving 54 participants (see Table 5 for demographic information). A 2 (University)×2 (Gender)×2 (Stereotypicality) analysis of variance (ANOVA) revealed no effects of university on any of the dependent variables, except that students at UW reported marginally more interest in computer science than students at Stanford, $F(1, 46)= 3.41$, $p=.07$. However, university did not interact with the manipulation of article nor with gender (and there was no three-way interaction), suggesting that the effects of the articles and gender were similar across the two universities. As a result, we combined across universities for analyses.

Table 5 Condition and demographic information of participants in Study 2 by gender and school

		Females (n=30)		Males (n=24)	
		Stanford (n=24)	UW (n=6)	Stanford (n=14)	UW (n=10)
Condition	Stereotypical	11 (45.8 %)	4 (67.7 %)	7 (50.0 %)	5 (50.0 %)
	Non-stereotypical	13 (54.2 %)	2 (33.3 %)	7 (50.0 %)	5 (50.0 %)
Age	*M* (*SD*)	18.58 (0.71)		18.86 (0.86)	
Race	White	9 (37.5 %)		5 (35.7 %)	
	Asian American	8 (33.3 %)		4 (28.6 %)	
	Latino	3 (12.5 %)		0	
	African American	1 (4.2 %)		0	
	Multiracial	2 (8.3 %)		5 (35.7 %)	
	Other/unidentified	1 (4.2 %)		0	
Year	Freshman	19 (79.2 %)		12 (85.7 %)	
	Sophomore	4 (16.7 %)		1 (7.1 %)	
	Junior	1 (4.2 %)		1 (7.1 %)	

Percentages calculated within gender and school

Procedure

Articles

Participants were randomly assigned to read one of two fabricated news articles created for this study. One article was entitled, *Study finds computer science continues to be dominated by "geeks"* (see Table 5 for the distribution of women and men in each condition). The other article was entitled, *Study finds computer science no longer dominated by "geeks."* The two articles were identical except when referring to claims about the stereotypical nature of the field (see Appendix for both articles). Articles were formatted to make them appear printed off of the internet.

Dependent Measures

Participants were instructed to summarize the main point of the article to ensure they had read it, and they then indicated their interest in computer science by agreeing or disagreeing with the statement, "I have considered majoring in computer science" on a scale of 1 (*strongly disagree)* to 7 (*strongly agree*) (see also Cheryan and Plaut 2010; Cheryan et al. 2009). This statement was presented with other filler statements (e.g., nervous using computers). To examine whether one article was more believable than the other, participants were asked two questions that were combined to form a measure of believability: how much they believed the trend in the article was true, on a scale from 1 (*do not believe at all*) to 7 (*strongly believe*), and how much they had observed the trend at their university, on a scale from 1 (*not at all*) to 7 (*very much*), $r(38)=.52$, $p=.001$. Only the first believability question was included for the UW sample. Demographic information, including gender and year in school, was assessed at the end.

Baseline Measure

To examine whether the stereotypical or non-stereotypical article (or both) influenced participants, we asked 62 students (33 women) who did not read an article (data also presented in Cheryan and Plaut 2010) the same question as above regarding their interest in majoring in computer science. Collecting baseline data at a different point in time has been used in previous experiments (e.g., Cheryan et al. 2009; Master et al. 2012), but results should nevertheless be interpreted cautiously.

Results

Believability of Articles

In order to ensure that participants believed that the articles were real, a 2 (Stereotypicality)×2 (Gender) ANOVA was run on believability. Results revealed no main effect of gender, $F(1, 50)=.21$, *ns*, and a marginal main effect of article, $F(1, 50)=3.73$, $p=.06$, $d=.48$. Participants believed the non-stereotypical article ($M=5.09$, $SD=1.09$) more than the stereotypical article ($M=4.46$, $SD=1.49$). This appeared to be driven by men, who believed the non-stereotypical article ($M=5.29$, $SD=.66$) significantly more than the stereotypical article ($M=4.08$, $SD=1.36$), $F(1, 50)=5.18$, $p=.03$, $d=1.13$. Women's believability did not differ between the non-stereotypical article ($M=4.93$, $SD=1.35$) and the stereotypical article ($M=4.77$, $SD=1.56$), $F(1, 50)=.12$, *ns,* although the Stereotypicality×Gender interaction was not significant, $F(1, 50)=2.14$, *ns*. Effects presented below remained upon controlling for believability of the articles.

Interest in Computer Science

A 2 (Stereotypicality)×2 (Gender) ANOVA revealed no main effects of gender, $F(1, 50)=.60$, *ns*, or stereotypicality,

$F(1, 50)=1.30$, *ns*, on how much participants considered majoring in computer science. However, as predicted, there was a marginal Stereotypicality×Gender interaction, $F(1, 50)=3.60$, $p=.06$. Women were significantly less likely to express interest in majoring in computer science after reading the stereotypical article ($M=1.53$, $SD=1.25$) compared to the non-stereotypical article ($M=3.20$, $SD=2.43$), $F(1, 50)=5.18$, $p=.03$, $d=.86$. In contrast, there was no difference in men's interest between the stereotypical ($M=3.00$, $SD=2.37$) and non-stereotypical ($M=2.58$, $SD=1.78$) articles, $F(1, 50)=.26$, *ns* (see Fig. 1).

Comparison to Baseline

In order to test our hypothesis that the non-stereotypical article will increase women's interest over baseline, a 3 (Stereotypicality: baseline, stereotypical, non-stereotypical)×2 (Gender) ANOVA was conducted on interest in computer science. Results revealed a marginal interaction, $F(2, 110)=2.53$, $p=.08$. Men's desire to major in computer science was the same across the three conditions, $F(2, 110)=.20$, *ns*, but women's desire to major in computer science depended on which article they read, $F(2, 110)=4.28$, $p=.02$. Pairwise comparisons revealed that women's interest was no different after reading the stereotypical article ($M=1.53$, $SD=1.25$) than at baseline ($M=1.70$, $SD=1.43$), *ns*. However, as predicted, the non-stereotypical article significantly increased women's interest in computer science ($M=3.20$, $SD=2.43$) compared to baseline, $p=.01$, $d=.75$, and compared to reading the stereotypical article, $p=.01$, $d=.86$.

Discussion

Exposure to a newspaper article claiming that computer science majors no longer fit current stereotypes increased women's interest in majoring in computer science compared to exposure to a newspaper article claiming that computer science majors fit the stereotypes. This difference in women's interest as a result of reading the articles appeared to be driven by the non-stereotypical article increasing women's interest over baseline, which is consistent with the fact that we used undergraduates' current stereotypes about computer science to generate the stereotypical article, thereby reflecting their current beliefs. Men, on the other hand, were unaffected by how computer science majors were represented.

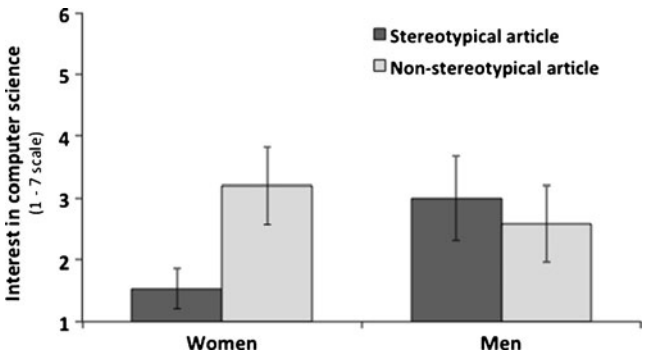

Fig. 1 Women's and men's interest in majoring in computer science after reading a newspaper article claiming computer science majors fit or did not fit current stereotypes in Study 2. Scale ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). Error bars represent standard errors

Broadening the image of the people in the field using media representations may help to recruit more women into male-dominated majors such as computer science. Moreover, the media may be a powerful transmitter of stereotypes and prevent many women from entering these fields. It should be noted that a limitation of this study was that data collection occurred with two different sources at two different times. Although no effect of source emerged, results should be interpreted with this in mind.

General Discussion

The present studies offer an explanation for why it has been difficult, despite years of effort, to recruit women into computer science. This explanation, at its core, involves the stereotypical representation of the computer scientist – an image that is pervasive in popular culture and in the minds of students as someone who is highly intelligent, singularly obsessed with computers, and socially unskilled. This image of the lone computer scientist, concerned only with technology, can be contrasted with a more people-oriented or traditionally feminine image, which was almost entirely absent in undergraduates' descriptions of computer science majors in our first study. Although current stereotypes are limited in their accuracy (Borg 1999; Clarke and Teague 1996), students continue to generate stereotypical perceptions when asked to describe the people in computer science. The fact that women who had taken a computer science class were less likely than those with less experience to rely on these classic stereotypes suggests that exposure to the field may be one way to change inaccurate perceptions.

Our second study used print media representations to manipulate computer science stereotypes and tested the consequences for women's and men's interest in the field. After reading a newspaper article claiming that computer science majors no longer fit the stereotypes, women, but not men, reported that they considered majoring in computer science to a greater extent than when they read that computer science was dominated by people who fit the stereotypes or read no article. Circulating alternate media images of computer science that portray the field as more diverse than current stereotypes suggest could increase women's interest in entering computer science. Such efforts may include highlighting counter-stereotypical role models, such

as newly appointed Yahoo! CEO Marissa Mayer, or showcasing the ways in which computer scientists can use their field to help society (e.g., the Dot Diva campaign). Using media outlets to change the stereotypes about computer scientists could accompany other vehicles of stereotype change, such as parents (Harackiewicz et al. 2012; Jacobs 1991), teachers (Beilock et al. 2010; Fennema et al. 1990), peers (Cheryan et al. 2011b; Paluck 2010), and university departments (e.g., the "Georgia Computes!" Program: http://gacomputes.cc.gatech.edu/). Media outlets (e.g., newspapers, internet blogs, commercials) may be particularly powerful agents of change because they have the potential to reach a large audience of different ages.

This research thus contradicts a popular conception that the shortage of women in computer science and other scientific fields is simply due to women's intractable lack of interest. We show here that preferences for majoring in computer science—far from being a stable characteristic— can be manipulated by media representations. The present findings cast doubt on the perception that decisions about college majors are "free" choices, and suggests that instead they are very much "constrained" by prevalent stereotypes (Ceci et al. 2009). When stereotypes that are incompatible with the way members of a group see themselves become associated with a particular academic field, they can steer people from that group away from that field. People who are potential group members (e.g., potential computer scientists) adjust their willingness to enter the group based on their stereotypes. In addition, this research speaks to the important role the media plays in attracting underrepresented groups to certain domains. Future research should explore the effects of computer science stereotypes among other populations, including younger populations and populations outside the U.S.

Conclusion

Why do women not constitute a higher proportion of computer science majors? We show that current stereotypes that depict computer scientists as intensely focused on computers and lacking interpersonal skills are widely known by undergraduates. These stereotypes are incongruent with characteristics women are expected to and may wish to possess, such as working with and helping others (Cejka and Eagly 1999; Diekman et al. 2011). A negative consequence of the circulation of these stereotypes in society is that they prevent women from developing an interest in these fields. We found that the pervasive "computer nerd" stereotype discourages women from pursuing a major in computer science. However, when this image is downplayed using print media, women express more interest in majoring in computer science. Efforts made by educators to attract more women into computer science may be rendered significantly less potent if the media continue to portray computer scientists in a way that is incompatible with how women see themselves. Increasing the participation of women in computer science may require diversifying the field by drawing attention away from stereotypical representations and towards other more inclusive and varied representations.

Appendix

Study finds computer science continues to be dominated by 'geeks'

By Pat Atkins, USA TODAY

The recent dot-com bubble may have burst, but no corresponding shift in the type of students attracted to computer science is occurring in universities across the country.

A recent study by researchers Christine M. Pearson of the University of North Carolina and Mike M. Yang of Temple University found a full third of computer science majors describe themselves as 'geeks,' a number similar to the one obtained several years ago.

The stereotypical techno-nerds, with their short-sleeve shirts and pencil protectors in their pockets, are just as easy to come by these days. According to Pearson, it is not difficult to "walk around a campus and pick out the students on their way to the computer science department."

Anyone can see that this image has profoundly been absorbed into the universal consciousness. The first image of a computer science major that pops into mind is still that of a pasty, willowy student in a dorky shirt, face hidden behind bangs and glasses.

Many image experts admit it: In a word association game, 'Computer Scientist = Geek' forever.

To observers, computer science continues to be ruled by geeks. And although the past few years has brought a new level of publicity to the field, the basic expectation of the major as populated by geeks who live and breathe programming endures.

Study finds computer science no longer dominated by 'geeks'

By Pat Atkins, USA TODAY

The recent dot-com bubble may have burst, but its impact on the type of students attracted to computer science in universities across the country appears to be here to stay.

A recent study by researchers Christine M. Pearson of the University of North Carolina and Mike M. Yang of Temple University found that only a third of computer science majors describe themselves as 'geeks,' a significant decline from even just a few years ago.

The stereotypical techno-nerds, with their short-sleeve shirts and pencil protectors in their pockets, are hard to come by these days. In fact, it is not difficult to walk around a campus and see a variety of students on their way to the computer science department.

Anyone can see that this change is slowly being absorbed into the universal consciousness. The first image of a computer science major that pops into mind might no longer be a pasty, willowy student in a dorky shirt, face hidden behind bangs and glasses.

Many image experts admit it: In a word association game, 'Computer Scientist = Geek' no longer.

To observers, computer science has undergone a degeeking. The seemingly less nerdy, more well-rounded, and generally more user-friendly student of late is a trend that many hope will mend the battered image of the computer science major.

Note: Articles were formatted to appear printed off the web.

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