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Original Article

Stereotype Threat in Virtual Learning Environments: Effects of Avatar Gender and Sexist Behavior on Women's Math Learning Outcomes

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Abstract

Women in math, science, and engineering (MSE) often face stereotype threat: they fear that their performance in MSE will confirm an existing negative stereotype—that women are bad at math—which in turn may impair their learning and performance in math. This research investigated if sexist nonverbal behavior of a male instructor could activate stereotype threat among women in a virtual classroom. In addition, the research examined if learners' avatar representation in virtual reality altered this nonverbal process. Specifically, a 2 (avatar gender: female vs. male) $\times$ 2 (instructor behavior: dominant sexist vs. nondominant or nonsexist) between-subjects experiment was used. Data from 76 female college students demonstrated that participants learned less and performed worse when interacting with a sexist male instructor compared with a nonsexist instructor in a virtual classroom. Participants learned and performed equally well when represented by female and male avatars. Our findings extend previous research in physical learning settings, suggesting that dominant-sexist behaviors may give rise to stereotype threat and undermine women's learning outcomes in virtual classrooms. Implications for gender achievement gaps and stereotype threat are discussed.

Keywords: virtual reality, stereotype threat, social identity, virtual learning, gender

Introduction

Gender achievement gaps—the achievement differences between male and female—are pervasive in the United States.[1,2] The gap that favors men in math, science, and engineering (MSE) domains is particularly subject to intense scrutiny.[1,2] Researchers believe that a primary psychological cause for women's underperformance in math is stereotype threat, a form of cognitive burden that stems from concerns of being judged as less capable because of an individual's social identity.[3] This study focuses on stereotype threat in virtual learning environments.

''Women are bad at math'' is a pervasive negative stereotype. Women majoring in MSE may experience stereotype threat—the fear of being judged as poor in math ability because of this stereotype. Although a well-established literature has suggested that stereotype threat hurts female learners' learning and performance in physical MSE settings,[4–10] it is important to examine if gender-based identity and stereotype threat plays out in virtual spaces, given the increasing use of virtual classrooms in math education.[11] Virtual classrooms allow people to use avatars—digital representations of themselves in computer-mediated communication[12]–as they learn. Therefore, it is important to investigate the understudied phenomenon of how avatar embodiment of gender can affect people's learning and performance in immersive virtual environments (IVEs).

This study aims to investigate (a) the effects of nonverbal behavior of a male instructor avatar on women's math learning and performance, with dominant-sexist behavior as a threatening cue and (b) how avatar gender may moderate the stereotype threat effect in IVE. The insights obtained through the study enhance understanding of how stereotype threat manifests in virtual environments (VEs) and suggest avenues for future educational research or areas where intervention may be needed to promote equitable learning environments.

Effects of stereotype threat on learning and performance

Women often face reminders of the negative stereotype that their achievements in MSE will be worse than men; this threat in turn impairs their learning and performance

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in these fields. Well-established research on stereotype threat suggests that compared with nonstigmatized group members, stigmatized individuals facing a negative group stereotype tend to underperform in a variety of learning-related tasks such as working memory (i.e., temporary storage of information),[13] learning (i.e., the ability to encode math rules necessary to solve problems),[6–8] and performance (i.e., the intellectual ability to accurately solve problems).[9,10]

A variety of situational cues in learning contexts can evoke stereotype threat, such as the salient representations of stereotypically masculine artifacts in the classroom (e.g., a Star Trek poster)[14] and the representation of men in numerical majority of the group.[15] Behavioral cues in social interactions have been shown to elicit stereotype threat as well. For example, women who interacted with a male partner with dominant and sexually interested behavior (i.e., looking at women's bodies, sitting close to women with open body posture) experienced deficits in an engineering task.[16] Van Loo and Rydell suggested that simply watching a video of another woman interacting with a sexist man reduced female viewers' math performance.[17] Furthermore, a field study found that professional female engineers who had negative work-related conversations with male colleagues on a given day experienced greater stereotype threat and burnout later in the same day.[18]

Stereotype threat in IVE

VEs refer to sensory information that leads to perceptions of a synthetic environment as nonsynthetic.[19] An IVE is one that presents a multisensory environment that responds to body movements, leading to greater psychological presence.[19] Virtual classrooms allow people to teach and learn a course in an IVE, providing more personalized and richer communication than other online educational technologies.[19] As digital educational programs have been increasingly common in postsecondary education,[20] it is important to understand how IVEs can change the social dynamics and outcomes of learning.

Previous research suggested that situational cues that trigger stereotype threat in physical settings have a similar effect in VEs. Cheryan et al. found that viewing a virtual computer science classroom that contained stereotypically masculine objects (e.g., science fiction books and electronics) reduced female students' intentions to enroll in the class.[21] In a virtual public speaking class, women spoke for a shorter amount of time than men when they were exposed to a picture of a male role model (e.g., Bill Clinton); this gender difference disappeared when a picture of a female role model (e.g., Hillary Clinton) was presented.[22] Given that dominant-sexist behavior by men (i.e., looking at women's bodies and sitting close to women with open body posture) has been shown to evoke stereotype threat in physical settings,[17] we expected the same social dynamic to hold in IVE, where there is an additional experimental benefit in that the behavior of a virtual male instructor avatar can be entirely programmed and thus controlled.[23]

H1: Dominant-sexist behavior from a male instructor will reduce women learners' math learning and performance in IVE compared with a nonsexist instructor.

Effects of avatar gender representation

Although IVE provides behavioral cues likely to evoke stereotype threat just as in physical settings, they uniquely afford people the ability to dramatically alter self-presentation and self-identity through an avatar (i.e., digital portrayals of oneself).[12] The Proteus effect is a prominent theory that suggests the cognitive and behavioral effects of avatar embodiment, which assumes that people think and behave in line with their avatars' appearances and characteristics, regardless of their own self-identity.[24,25] For example, participants represented with more attractive and taller avatars in IVE were more "intimate in self-disclosure and more confident in a negotiation task" than those represented with less attractive and shorter avatars.[24] More specific to gender representation, research has shown that game players using female avatars performed more healing activities, whereas players using male avatars engaged in more aggressive combating activities, regardless of participants' actual gender.[26] In a study using a computer screen display, participants who embodied a male avatar and competed against two female avatars performed better on an arithmetic task than participants embodied by a female avatar competing against two male avatars.[27]

Drawing on the Proteus effect, avatar gender may moderate stereotype threat effects in virtual MSE learning environments. Female learners represented by male avatars may perceive the male avatar characteristics as relevant to self-concept and internalize the male identity, thereby being less susceptible to the threatening cues associated with the negative stereotype about women during the learning session. Therefore, it is reasonable to predict that women represented by male avatars can learn and perform math tasks more successfully than those using female avatars in virtual classrooms where stereotype threat is induced.

However, stereotype activation theory provides an alternative perspective on how avatar gender representation may affect stereotype threat effects.[28] The theory suggests that physical traits (e.g., race and gender) can automatically activate stereotypes associated with the marginalized social groups. While virtual reality (VR) embodiment allows people to alter their digital identities (e.g., a woman can be embodied by a male avatar), altering gender—usually understood to be a relatively stable physical trait—may only make it more salient, which in turn could further trigger stereotyped thoughts about the gender. In support of the activation hypothesis, Groom et al. found that people embodied by a black avatar (with head-tracking only) showed greater preference for white people than those embodied by a white avatar, regardless of participants' race.[29] Lopez et al. found that male participants embodied by a female avatar (with full-body tracking) in VR exhibited increased implicit gender bias, compared with those embodied by a male avatar.[30] Therefore, representation by a male avatar in IVE could simply draw more attention to one's female identity, especially in a negatively stereotyped scenario when interacting with a dominant-sexist male instructor. If so, body swapping could trigger greater stereotype threat and further undermine learning or performance among women embodying male avatars.

Given the competing hypotheses, we asked,

RQ1: Will the avatar gender of women learners moderate the effects of instructor behavior on learners' math learning and performance?

Little research has examined the effects of behaviorally threatening cues in virtual classroom on women's math learning and it is unclear if VR avatar embodiment can effectively prevent women's math learning from stereotype threat; the present study will address these gaps in a controlled experiment using a head-tracking IVE system.

Methods

Participants

We conducted *a priori* power analysis to ensure a sufficient sample for this study. A power analysis using a moderate effect size of $d = 0.36$ based on a meta-analysis,[31] a significance level of 0.05, powered at 80 percent, required a total of 78 participants to find an effect.

A total of 89 female undergraduate students enrolled at a private university took part in the study in exchange for either course credit or $15. Only female students were recruited because the present research examined the effects of avatar gender on math learning outcomes, and women were overall more likely to suffer from stereotype threat than men on math achievement.[4] Our final sample size after exclusions ($N = 76$)[a] almost met the threshold from the power analysis. About 42.1 percent of the participants ($n = 32$) majored in MSE and 57.9 percent ($n = 44$) in non-MSE disciplines. All participants indicated no previous knowledge of modular arithmetic (MA) math.

Design and Procedure

This study obtained the approval of the university Institutional Review Board. A 2 (avatar gender: female vs. male) × 2 (instructor behavior: sexist vs. nonsexist) between-subjects experimental design was used.

Manipulations. Participants were randomly assigned to be represented by either a college-aged white female or male avatar. Participants were then randomly assigned to interact with a male avatar instructor whose nonverbal behavior toward the participants' avatar was either dominant and sexist or nondominant and nonsexist. The dominant behavior aimed to elicit stereotype threat that involved sitting with open body posture (i.e., shoulders leaned back and legs apart) relatively close to the participant's avatar and alternating between making direct eye contact with the participant and glancing at the participant's avatar's body. In contrast, nondominant behavior involved sitting further from the participant's avatar with a closed body posture (i.e., legs crossed and body turned slightly away) and alternating between eye contact with the participant and looking at the ground.

Procedure. Upon arriving at the experiment site, participants were told that the study examined how people would learn in virtual reality and that they would learn a novel type of math called MA from an avatar instructor controlled by a graduate student in another room whom they had not met before. In reality, the avatar instructor was programmed and animated to provide identical pedagogical content to all participants. The virtual classroom contained a projector screen that displayed slides for the math lesson and a video monitor that showed the participant's avatar in real time (Fig. 1). Both the video monitor and the avatar instructor were in the participant's field of vision throughout the entire learning period.

Participants then put on the virtual reality head-mounted display equipment[b] and learned a virtual math course for ~10 minutes with an avatar instructor. The avatar instructor explained the math learning objectives through slides on the projection screen and occasionally provided additional prerecorded explanations throughout the lesson. Upon finishing the experiment, participants left the virtual classroom and completed a questionnaire measuring math learning and performance on a desktop computer.

Materials and Measures[c]

We adopted an MA learning task from Rydell et al.[10] to examine both math learning and performance. MA is a mathematical task where participants learn a modulus function, which consists of an equation with three parameters: a = b (mod n). The modulus function is solved by a series of arithmetic operations: (a − b)/n. If the answer to the modulus function is an integer value, then the modulus function is true [e.g., 17 = 5 (mod 6)]. Conversely, if the

[a]Of the 89 total participants, 13 were excluded from analysis because of technical issues with the virtual reality equipment during their experimental trial ($n = 7$), because they failed the avatar gender manipulation check ($n = 1$), because they guessed one of the manipulations ($n = 1$), or because they did not complete the trial (nausea [$n = 1$], near-sightedness [$n = 1$], or dyslexia [$n = 1$] preventing them from clearly viewing the math lesson in the virtual environment; cheating on the modular arithmetic explanation task [$n = 1$]). Thus, the analyses reflect data from 76 participants.

[b]The head mounted display used was a nVisor SX with dual 1,280 horizontal × 1,024 vertical pixel resolution panels. Head-mounted displays consist of optical projection goggles fitted with a motion-tracking system that synchronizes with a server to continuously update the user's virtual field of vision during head movement through physical space. Participants were led through a series of tracking exercises for 90 seconds and then were asked to track their physical movements on the video monitor in the virtual classroom. These procedures aimed to make participants aware of the presentation of their own avatar's gender identity and pay attention repeatedly but covertly to their virtual identity.

[c]Given the potential roles of individuals' virtual experience and the level of self-relevance of learning math indicated in previous literature,[33] we measured individuals' sense of presence in the virtual environment, math identification, and educational background as covariates. Presence was a three-dimensional construct involving self, social, and spatial presence.[23] Participants rated the extent to which they felt that (a) they authentically embodied their virtual self (i.e., self-presence), (b) the virtual instructor was present (i.e., social presence), and (c) they were actually inside the classroom (i.e., spatial presence) on five-point Likert scales from 1 = never to 5 = always. The items were averaged into an index of presence ($M = 3.10$, standard deviation [SD] = 0.76, Cronbach's $\alpha = 0.65$). Math identification was a single-item scale assessing the importance for participants to do well in math. The scale was measured on a five-point Likert scale from 1 = not at all important to 7 = exceptionally important ($M = 4.78$, standard deviation [SD] = 0.89).

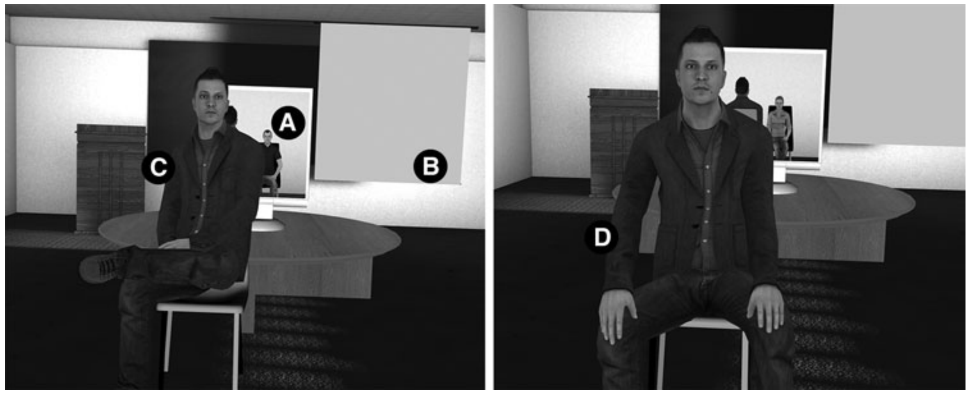

FIG. 1. Participants were represented by (A) a male or female avatar in a virtual classroom that contained (B) a projector screen that displayed instructional slides for the MA math learning task. Participants interacted with (C) a nonsexist tutor with neutral body posture or (D) a sexist tutor who sat closer to them with sexually dominant body posture. MA, modular arithmetic.

answer is not an integer value, then the modulus function is false [e.g., 19 = 7 (mod 7)].

MA learning. Participants were asked to complete a questionnaire on a lab computer after leaving the virtual classroom, where they first provided a step-by-step explanation of how to solve an MA problem. The explanations were independently rated by two condition-blind coders on a Likert-type scale from 1 = very poor to 5 = excellent. The MA explanation score was the average of two independent ratings for each participant ($M = 3.13$, standard deviation [SD] = 1.83, Krippendorff's $\alpha = 0.89$).

MA performance. Participants were asked to solve 54 MA problems. The number of problems correctly solved was used to measure math performance (min = 25, max = 54, $M = 47.37$, $SD = 8.80$). Accuracy score was positively correlated with explanation score ($r = 0.77$, $p < 0.05$).

Data Analysis and Results

Data analysis

Because this study aimed to examine effects of stereotype threat and avatar gender representation on both math learning and performance and these two measures were closely associated, we examined the effects on performance by statistically controlling for learning score.[10] We conducted a two-way analysis of variance (avatar gender × instructor behavior) to examine the effects on MA learning, and conducted a two-way analysis of covariance for MA performance, including participants' MA learning score as a covariate. To avoid violating the assumption of normality for both tests, we performed square root transformation for both MA explanation and accuracy scores to address the negative skewness. For ease of interpretation, we reported the untransformed mean values and standard error (SE).

Results[d]

MA learning. The main effect of instructor behavior was significant, $F(1, 72) = 3.98$, $p = 0.05$, $\eta^2 = 0.05$, suggesting that women performed worse on MA explanations when learning from a dominant-sexist instructor ($M = 2.75$, $SE = 0.29$) than from a nondominant instructor ($M = 3.55$, $SE = 0.30$). However, neither the main effect of avatar gender, $F(1, 72) = 0.31$, $p = 0.58$, $\eta^2 < 0.005$, nor the interaction effect between avatar gender and instructor behavior was significant, $F(1, 72) = 0.05$, $p = 0.83$, $\eta^2 < 0.005$ (Fig. 2).

MA performance. Controlling for MA learning score, the main effect of instructor behavior was significant, $F(1, 71) = 13.62$, $p < 0.001$, $\eta^2 = 0.08$, suggesting that women correctly solved fewer MA problems when learning from a dominant-sexist instructor ($M = 45.10$, $SE = 1.36$) than from a nondominant instructor ($M = 49.92$, $SE = 1.44$). Nonsignificant results were observed for the main effect of avatar gender, $F(1, 71) = 0.07$, $p = 0.79$, $\eta^2 < 0.005$, and the interaction effect between avatar gender and instructor behavior, $F(1, 71) = 0.32$, $p = 0.58$, $\eta^2 < 0.005$ (Fig. 3).

Discussion

This study found that interacting with a male instructor with dominant and sexist nonverbal behavior undermined women's math learning and performance on a math task, which suggests that behavioral cues in social interaction can evoke stereotype threat in IVE. However, avatar gender did not significantly impact women's math learning and performance when interacting with a dominant and sexist instructor, suggesting that it did not affect women's experiences of stereotype threat. This is inconsistent with both the Proteus effect and the stereotype activation theory.

This study has several theoretical and practical implications. First, this study parallels the move of situational cues from offline settings to virtual classrooms.[21,22] It extends previous research[16] showing that nonverbal behavior as evaluative of a negatively stereotyped ability (here,

[d]In preliminary analyses, a series of t-tests revealed that participants majoring in math, science, and engineering (MSE) ($M = 5.09$, $SD = 0.85$) reported higher level of math identification than those majoring in non-MSE ($M = 4.55$, $SD = 0.70$), $t(58) = 2.98$, $p < 0.05$. Participants represented by female avatar ($M = 3.35$, $SD = 0.77$) reported higher level of presence in immersive virtual environment (IVE) than those represented by male avatar ($M = 2.89$, $SD = 0.70$), $t(72) = 2.85$, $p < 0.05$. Analysis of covariances were then conducted to predict modular arithmetic learning and performance with educational background (1 = MSE, 0 = non-MSE), math identification and level of IVE presence as possible covariates, but neither was significant (Fs < 1). Controlling for these covariates, findings in the main analyses remained. Therefore, we removed covariates from the main analyses.

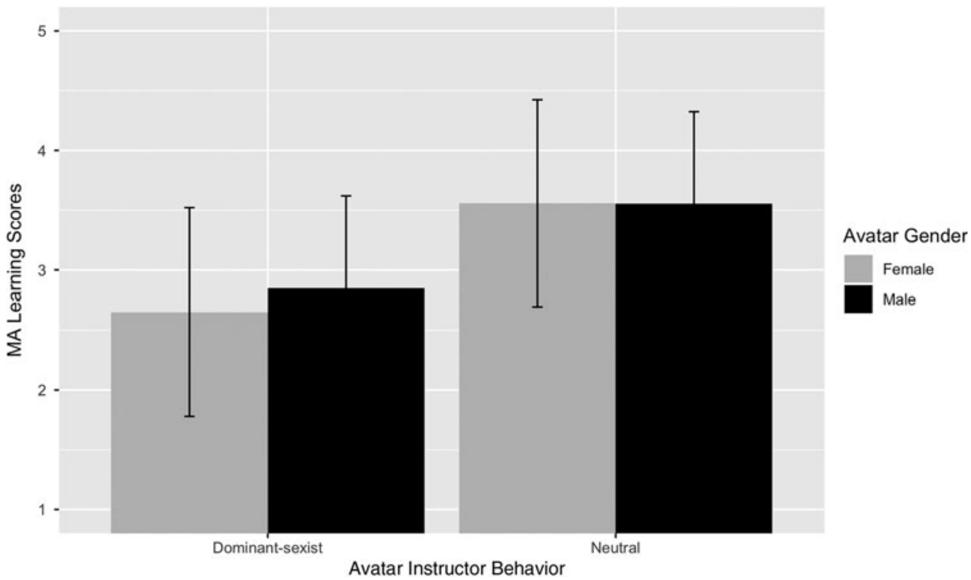

FIG. 2. Effects of avatar gender and avatar tutor behavior on MA learning scores. *Bars* represent estimated marginal means by conditions. Error bars denote 95 percent confidence interval.

dominant-sexist behavior) can undermine women's learning in IVE as it can do in physical classroom. Therefore, other threatening cues such as negative conversations and facial expressions in offline interactions[17,18] may also trigger stereotypes about women in IVEs and therefore cause women to underperform in math compared with men. Future research could examine this possibility in virtual classrooms and other forms of educational technologies. This finding also has implications for less immersive but more pervasive educational technologies, such as course website interfaces,[32] Massive Open Online Courses,[33] and online games.[34] Educational practitioners on these platforms should closely monitor and remove nonverbal cues, such as in lecture videos, that are likely to trigger stereotype threat.

Second, recall that the Proteus effect[24] suggests that people tend to behave consistently with their digital self-representation, whereas the stereotype activation theory predicts that people conform to stereotypes of their own self-identity when stereotypes are activated.[28] Our findings supported neither hypothesis, demonstrating, instead, that avatar gender did not intensify or alleviate the stereotype threat effect on math learning-related tasks. Drawing on previous work also showing the null result of avatar gender,[35–37] it is possible that self-identified gender is more salient to individuals than the gender of an assigned avatar during the avatar-based learning task. The lack of self-relevance to the avatar gender may not sufficiently activate stereotypical thoughts about women's underperformance in math, and thus may inhibit the avatar gender effects, especially during the postuse assessment tasks.[35,36] Furthermore, unlike previous research that used Implicit Association Tests as indicators of gender/race bias,[29,30] participants in our study engaged in a cognitively demanding task of learning and applying a math rule. They may not have been able to devote cognitive resources to internalizing the identity of their assigned avatars, thus mitigating potential differences in stereotype activation

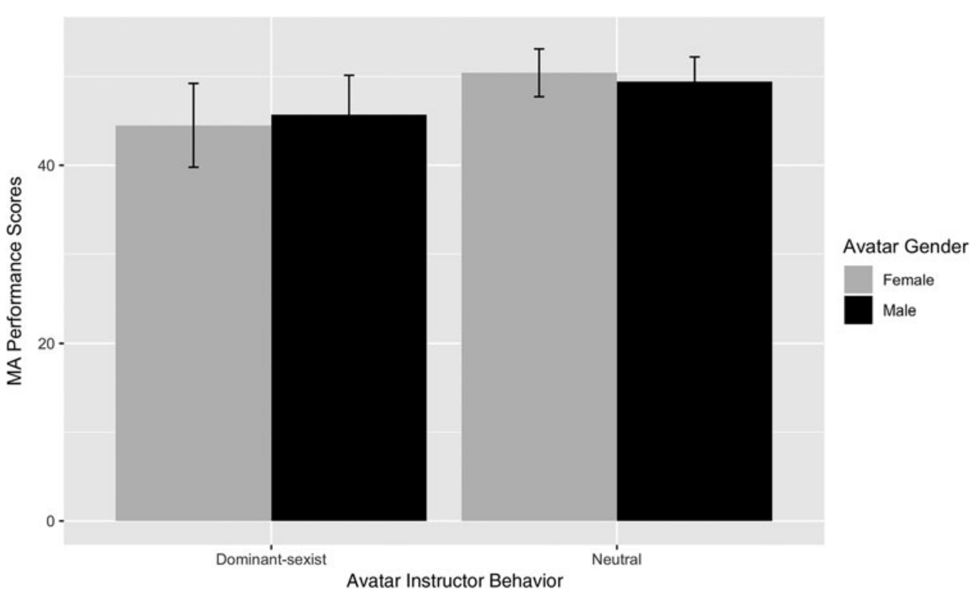

FIG. 3. Effects of avatar gender and avatar tutor behavior on MA performance scores. *Bars* represent estimated marginal means by conditions. Error bars denote 95 percent confidence interval.

from female versus male avatar representation. Finally, the null result of avatar gender may be because of a low statistical power based on a relatively small number of participants in this study ($N=76$). Future research should explore potential factors that may impact the effects of avatar gender on stereotype threats and math learning-related tasks, including self-relevance and the difficulty of math tasks, to better understand whether and when avatar embodiment can affect gender-based stereotypical thoughts using a larger sample.

This study has limitations. First, the study did not collect data on participants' race, which may limit interpretation and generalization of the findings. Because the avatars of both the male instructor and the learner were programmed as white, it is possible that nonwhite participants may perceive greater level of disconnection with the avatar than white participants. Second, although participants were able to see their avatar representations' gender during the virtual math course, they were not visually reminded of their avatars' gender during the assessment tasks (i.e., learning and performance) outside VR. Therefore, their associations and attachments with their assigned avatars' gender may diminish after avatar use, leading to the null effect of avatar gender. Future research could program the assessment tasks in VR settings, as opposed to a desktop computer afterward, to provide clear evidence that the effect is on both learning and performance. Third, although this study considered several key individual differences (i.e., math identification, MSE background, and sense of avatar presence), some factors remained unexamined, such as gender identification[38] (i.e., perceived importance of being a woman to one's self-concept) and gender stereotypical beliefs[36] (i.e., the extent to which people internalize related gender stereotypes in immediate tasks). Future research should consider these variables that may reinforce or mitigate the effects of stereotype threats among female learners.

Conclusion

Virtual learning environments offer an exciting range of opportunities to explore interpersonal dynamics including how they contribute to stereotype threat. This experiment extends past research on stereotype threat from in-person settings to IVEs, highlighting the potential harm of nonverbal behavioral cues on women's learning and performance in math through evoked stereotype threat. The results show that interventions will be necessary to overcome stereotype threat in virtual learning environments. Avatar designers must be mindful of these findings when creating ''stock'' animations to be used in video games, IVEs, and other virtual learning forums.

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References

1. Reardon SF, Fahle EM, Kalogrides D, et al. Gender achievement gaps in U.S. school districts. American Educational Research Journal 2019 [Epub ahead of print]; DOI: 10.3102/0002831219843824.
2. Robinson JP, Lubienski ST. The development of gender achievement gaps in mathematics and reading during elementary and middle school: examining direct cognitive assessments and teacher ratings. American Educational Research Journal 2011; 48:268–302.
3. Spencer SJ, Steele CM, Quinn DM. Stereotype threat and women's math performance. Journal of Experimental Social Psychology 1999; 35:4–28.
4. Nosek BA, Smyth FL, Sriram N, et al. National differences in gender–science stereotypes predict national sex differences in science and math achievement. Proceedings of the National Academy of Sciences United States of America 2009; 106:10593–10597.
5. Steele CM, Spencer SJ, Aronson J. (2002) Contending with group image: the psychology of stereotype and social identity threat. In *Advances in experimental social psychology.* Vol 34. Cambridge, MA: Academic Press, pp. 379–440.
6. Rydell RJ, Boucher KL. (2017) Chapter two-stereotype threat and learning. In Olson JM, ed. *Advances in experimental social psychology*. Cambridge, MA: Academic Press, pp. 81–129.
7. Rydell RJ, Shiffrin RM, Boucher KL, et al. Stereotype threat prevents perceptual learning. Proceedings of the National Academy of Sciences United States of America 2010; 107:14042–14047.
8. Taylor VJ, Walton GM. Stereotype threat undermines academic learning. Personality and Social Psychology Bulletin 2011; 37:1055–1067.
9. Inzlicht M, Ben-Zeev T. A threatening intellectual environment: why females are susceptible to experiencing problem-solving deficits in the presence of males. Psychological Science 2000; 11:365–371.
10. Rydell RJ, Rydell MT, Boucher KL. The effect of negative performance stereotypes on learning. Journal of Personality and Social Psychology 2010; 99:883.
11. Borba MC, Askar P, Engelbrecht J, et al. (2017) Digital technology in mathematics education: research over the last decade. In *Proceedings of the 13th International Congress on Mathematical Education*. Cham, Switzerland: Springer, pp. 221–233.
12. Bailenson J, Blascovich J. (2004). Avatars. In Bainbridge WS, ed. *Encyclopedia of human-computer interaction*. Barrington, MA: Berkshire Publishing Group, pp. 64–68.
13. Schmader T, Johns M. Converging evidence that stereotype threat reduces working memory capacity. Journal of Personality and Social Psychology 2003; 85:440.
14. Cheryan S, Plaut VC, Davies PG, et al. Ambient belonging: how stereotypical cues impact gender participation in computer science. Journal of Personality and Social Psychology 2009; 97:1045–1060.
15. Murphy MC, Steele CM, Gross JJ. Signaling threat: how situational cues affect women in math, science, and engineering settings. Psychological Science 2007; 18:879–885.
16. Logel C, Walton GM, Spencer SJ, et al. Interacting with sexist men triggers social identity threat among female engineers. Journal of Personality and Social Psychology 2009; 96:1089.
17. Van Loo KJ, Rydell RJ. Negative exposure: watching another woman subjected to dominant male behavior during a math interaction can induce stereotype threat. Social Psychological and Personality Science 2014; 5:601–607.
18. Hall WM, Schmader T, Croft E. Engineering exchanges: daily social identity threat predicts burnout among female

engineers. Social Psychological and Personality Science 2015; 6:528–534.

19. Bailenson JN, Yee N, Blascovich J, et al. The use of immersive virtual reality in the learning sciences: digital transformations of teachers, students, and social context. The Journal of the Learning Sciences 2008; 17:102–141.
20. Barbour MK, Reeves TC. The reality of virtual schools: a review of the literature. Computers and Education 2009; 52:402–416.
21. Cheryan S, Meltzoff AN, Kim S. Classrooms matter: the design of virtual classrooms influences gender disparities in computer science classes. Computers and Education 2011; 57:1825–1835.
22. Latu IM, Mast MS, Lammers J, et al. Successful female leaders empower women's behavior in leadership tasks. Journal of Experimental Social Psychology 2013; 49:444–448.
23. Blascovich J, Loomis J, Beall AC, et al. Target article: immersive virtual environment technology as a methodological tool for social psychology. Psychological Inquiry 2002; 13:103–124.
24. Yee N, Bailenson J. The Proteus effect: the effect of transformed self-representation on behavior. Human Communication Research 2007; 33:271–290.
25. Yee N, Bailenson JN, Ducheneaut N. The Proteus effect: implications of transformed digital self-representation on online and offline behavior. Communication Research 2009; 36 [Epub ahead of print]; DOI: 10.1177/0093650208330254.
26. Yee N, Ducheneaut N, Yao M, et al. (2011) Do men heal more when in drag? Conflicting identity cues between user and avatar. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, Vancouver, Canada. ACM, pp. 773–776.
27. Lee J-ER, Nass CI, Bailenson JN. Does the mask govern the mind? Effects of arbitrary gender representation on quantitative task performance in avatar-represented virtual groups. Cyberpsychology, Behavior, and Social Networking 2014; 17:248–254.
28. Bargh JA, Chen M, Burrows L. Automaticity of social behavior: direct effects of trait construct and stereotype activation on action. Journal of Personality and Social Psychology 1996; 71:230–244.
29. Groom V, Bailenson JN, Nass C. The influence of racial embodiment on racial bias in immersive virtual environments. Social Influence 2009; 4:231–248.
30. Lopez S, Yang Y, Beltran K, et al. (2019) Investigating implicit gender bias and embodiment of white males in virtual reality with full body visuomotor synchrony. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. CHI'19*. Paper No: 557. New York: ACM, pp. 1–12.
31. Nguyen H-HD, Ryan AM. Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. Journal of Applied Psychology 2008; 93:1314.
32. Metaxa-Kakavouli D, Wang K, Landay JA, et al. (2018) Gender-inclusive design: sense of belonging and bias in web interfaces. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. CHI'18*. New York: ACM, pp. 614.1–614.6.
33. Kizilcec RF, Halawa S. (2015) Attrition and achievement gaps in online learning. In *Proceedings of the Second (2015) ACM Conference on Learning @ Scale-L@S'15*. Vancouver, Canada: ACM Press, pp. 57–66.
34. Albuquerque J, Bittencourt II, Coelho JAPM, et al. Does gender stereotype threat in gamified educational environments cause anxiety? An experimental study. Computers and Education 2017; 115:161–170.
35. Ratan R, Sah YJ. Leveling up on stereotype threat: the role of avatar customization and avatar embodiment. Computers in Human Behavior 2015; 50:367–374.
36. Sherrick B, Hoewe J, Waddell TF. The role of stereotypical beliefs in gender-based activation of the Proteus effect. Computers in Human Behavior 2014; 38:17–24.
37. Kaye LK, Pennington CR, McCann JJ. Do casual gaming environments evoke stereotype threat? Examining the effects of explicit priming and avatar gender. Computers in Human Behavior 2018; 78:142–150.
38. Schmader T. Gender identification moderates stereotype threat effects on women's math performance. Journal of Experimental Social Psychology 2002; 38:194–201.

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