4-15-2020

Do Hardworking Role Models Lower Implicit Gender-Science Bias?

Christina Garasky
University of Missouri-St. Louis, cegmkf@mail.umsl.edu

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Christina E. Garasky

B.S. Neuroscience, University of Minnesota, 2018

A Thesis Submitted to The Graduate School at the University of Missouri-St. Louis
in partial fulfillment of the requirements for the degree
Master of Arts in Psychology
with an emphasis in Behavioral Neuroscience

May 2020

Advisory Committee

Bettina J. Casad, Ph.D.
Chairperson

Sandra E. Langeslag, Ph.D.

Suzanne E. Welcome, Ph.D.

Abstract

Prior research has demonstrated that implicit gender-science biases discourage women from pursuing careers in science, technology, engineering, and math (STEM). Gender-science biases promote the belief that women cannot be successful in STEM, which can affect women's sense of belonging and commitment to STEM. While women scientists serving as role models benefit women in STEM by decreasing implicit gender-science biases and increasing perceived belonging and performance in STEM, the influence of role model qualities on implicit bias has not been widely explored. The current study examined the influence role model qualities (hardworking, gifted) have on implicit gender-science bias. The research also explored whether individual differences, such as women's perception of their possible science selves and implicit intelligence theories, moderate the relationship between role model qualities and STEM outcomes (e.g., bias and self-perceptions). Participants (N = 41) completed an online questionnaire, which assessed the individual differences of science possible selves and implicit intelligence theories as moderators and completed a measure of implicit gender-science bias. In the lab, participants watched a documentary-style video featuring a hardworking (or gifted) woman scientist role model. Participants then completed the measure of implicit gender-science bias while their electrophysiological indices of implicit bias (N400, N200) were assessed. Results indicated that role model qualities (hardworking, gifted) do not influence implicit gender-science bias, and that science possible selves and implicit intelligence theories do not moderate this relationship. These results do not support prior research but can aid in the development of more effective role model manipulations in lab settings.

Do Hardworking Role Models Lower Implicit Gender-Science Bias?

Although women's representation in male-dominated fields has continued to increase over the past few decades, unequal gender distribution persists within many of these fields. Women earn a larger percentage (54.8%) of bachelor's degrees than men (NSF, 2019); however, this is mainly due to women earning more bachelor's degrees in education, humanities, and social sciences, whereas women earn fewer degrees in many science fields (e.g., physics, chemistry; Ceci & Williams, 2011; NSF, 2019). Even though interest in STEM subjects is comparable between genders, fewer women enter STEM fields. Additionally, retention rates for women working in STEM are vastly lower compared to men in those same fields, diminishing women's representation in STEM (Ceci & Williams, 2011). Half the women in STEM careers leave the field within five years, a turnover rate twice as high as that of women in most non-STEM fields (Annabi & Lebovitz, 2018).

Research has examined explanations for women's lower retention rates in STEM, such as concerns about achieving work life balance (Bagilhole, Powell, Barnard, & Dainty, 2008); however, this reason did not fully account for the disproportionate attrition. Additionally, companies have implemented interventions aimed at increasing diversity and inclusion, developing methods to address organization climate and increase women's senses of personal agency, or the sense of control someone has over their actions, yet underrepresentation persists (Annabi & Lebovitz, 2018).

A main factor contributing to workplace attrition is the gender barriers many women must overcome in the workplace (Fouad, Singh, Cappaert, Chang, & Wan, 2016). These barriers often include microaggressions, or verbal or nonverbal derogatory slights toward a minority group, that can lead women to experience prejudice, feel isolated, and endure biased performance evaluations (Torino, Rivera, Capodilupo, Nadal, & Sue, 2018). These negative experiences occur in part because of stereotypes that favor men in the workplace (Lesko & Corpus, 2006).

Workplace gender stereotypes often favor men (Ridgeway & Correll, 2004), such as the common belief that women are more communal and nurturing and that men are more independent and competitive (Gupta, Han, Mortal, Silveri, & Turban, 2018). Independence and competitiveness are stereotypically masculine characteristics that people associate with being successful in STEM, further contributing to implicit gender-science bias (Fouad et al., 2016). These biases not only make prejudice and discrimination from men more likely, but also affect how women view themselves in the workplace, making it difficult for women to feel that they belong in STEM (Milkman, Akinola, & Chugh, 2015). The resulting feelings of isolation can cause women to develop negative attitudes toward STEM and decrease their work performance, ultimately leading to higher attrition rates (Lesko & Corpus, 2006).

It is essential to identify effective ways to reduce implicit gender-science biases to lower attrition rates and obtain equal representation in STEM fields. The purpose of the current study was to examine the extent to which women scientist role models can reduce implicit science bias toward women in STEM. To put this study into context, the following sections review the literature on possible influences that role models might have in reducing implicit bias.

Implicit Bias

Implicit biases are unconscious beliefs based on implicit attitudes or stereotypes (Greenwald & Banaji, 1995). Implicit biases are malleable and can elicit behaviors that are incongruent with a person's values (Fazio & Olson, 2003; Gawronski & Bodenhausen, 2006). These biases can be favorable or unfavorable, reflecting beliefs about positive or negative traits. Positive implicit biases can create ingroup bias or favoritism toward one's own group. This favoritism can create unity and a sense of belonging (Dasgupta, 2011). Negative implicit biases associate minority groups and their members with negative characteristics or stereotypes, which has repercussions like the underrepresentation of women in STEM fields.

Implicit social stereotypes are associations between a specific group and a trait (Greenwald & Banaji, 1995). Such associations may be based on a statistical reality but often are not, and group level statistics are overgeneralized in judgments of individuals (Kite & Whitley, 2016). For example, the stereotype that athletes possess physical stamina reflects a statistical reality because most athletes do have greater physical stamina than non-athletic individuals. However, when a social stereotype develops for a specific group and for a trait that does not have statistical backing, the implicit biases cause discriminatory favoritism, resulting in disadvantages for those belonging to a minority group. For example, the social stereotype that women do not have the (masculine) qualities required to be successful in STEM contributes to their disproportionate representation in STEM (Gupta et al., 2018).

In environments with high levels of implicit bias, women often develop stereotype attribution bias, or the tendency to attribute their failures in STEM to internal, stable causes, rather than recognizing the influence of environmental factors (Sekaquaptewa, 2011). Working in unwelcoming environments can lead women to endorse stereotypical views of their own abilities in STEM, which affects their job performance, science identity, and commitment to STEM (Sekaquaptewa, 2011). An environment is considered unwelcoming not only when one experiences or perceives negative treatment towards women, but also when women are merely the numeric minority (Sekaquaptewa, 2011). Poorer performance by women in STEM strengthens perceivers' stereotypes and leads to even stronger implicit bias. The current study aimed to explore ways to combat these stereotypes and subsequently reduce implicit gender-science bias in STEM.

Influences on Role Model Effectiveness

Benefits of role models. Research shows that women role models can be highly effective and beneficial. For women, same-gender science role models increase science identity and women's sense of belonging in STEM (Rosenthal, Levy, London, Lobel, & Bazile, 2013). This sense of belonging, in turn, increases women's retention in these fields (Cheryan & Plaut, 2010), and encourages higher academic aspirations, academic engagement, and commitment to STEM (Shin, Levy, & London, 2016). Women role models also benefit men, leading to higher math test performance for men exposed to a woman role model compared to men not exposed to a role model (Bagès, Verniers, & Martinot, 2016). Additionally, a greater female student presence in engineering classrooms reduced explicit stereotypical views among men who initially rejected stereotypical male superiority but did not significantly reduce such views for men who endorsed stereotypical views of male superiority (Riegle-Crumb, Moore, & Buontempo, 2017). However, exposure to a female teacher, as opposed to a male teacher, reduced explicit stereotypical views for men who initially endorsed male superiority. These findings suggest that women role models (e.g., women teachers) can benefit men and women and can reduce men’s explicit stereotypical views even among those who endorse stereotypical gender roles.

Previous research has also examined how famous counter-stereotypical women leaders affect women's implicit leadership bias or favoring men over women in leadership positions (Dasgupta & Asgari, 2004). Dasgupta and Asgari (2004) found that women role models can significantly reduce women's implicit gender-science bias. It is also known that certain qualities of role models are more beneficial than others; however, whether these qualities influence implicit bias has not been examined. Role models who demonstrate positive attributes are the most beneficial for women. By portraying themselves as respectful and honest individuals, who are knowledgeable and enthusiastic about their work, role models are more likable (Elzubeir & Rizk, 2008). Furthermore, implicit bias research demonstrates that viewing a likable role model has a stronger effect on reducing implicit gender-leadership bias (Young, Rudman, Buettner, & McLean, 2013), demonstrating that implicit bias may be influenced by how we perceive role models.

Being inspiring, similar to the mentee, and having attainable achievements are critical qualities for being an effective role model (Lockwood & Kunda, 1997; Rosenthal et al., 2013); however, these specific qualities have yet to be addressed in implicit bias research. More research is needed to understand whether and how being inspiring, relatable, and having attainable achievements (e.g., hardworking) in STEM, indeed, lowers implicit gender-science bias. Demonstrating these characteristics is essential because they allow the role model to exemplify a path to reach one's goals (Lockwood et al., 2002); which, in turn, may help women in STEM to develop an attachment to the role model and to STEM.

Possible selves' theory. The possible selves' theory states that individuals strive to attain or shy away from positive or negative imagined future versions of themselves (Beier, Miller, & Wang, 2012; Markus & Nurius, 1986; Oyserman & Fryberg, 2006). A possible self refers to the future individual one wishes to become or wants to avoid becoming, based on an individual's aspirations, ideals, and values (Beier et al., 2012). Positive possible selves are images of a person one wishes to become in the future, whereas negative possible selves are images that one works to avoid becoming. Research has shown that a strong science possible self promotes a desire for a career in science, demonstrating that possible selves can influence career choices (Wonch Hill et al., 2017).

Role models often influence possible selves by demonstrating a path that can be taken to reach one's goals. People perceive a role model's behaviors as a roadmap to reach their possible selves, and they often develop similar behavioral strategies necessary to meet their specific goals (Lockwood, Jordan, & Kunda, 2002). For example, if a role model gained professional connections by completing an internship, the individuals influenced by the role model would be more likely to take a related path, such as completing an internship to make similar professional connections. This successful behavioral strategy allows the individual to identify a track they can follow to make progress towards and eventually reach their goals. This increases the likelihood that the individual may attain success, which strengthens their possible selves (Markus & Nurius, 1986).

Role models who demonstrate successful behaviors are more influential in developing other people's possible selves (Lockwood et al., 2002). Individuals who have stronger science possible selves might be more inclined to follow their role model's behavioral strategies. This may lead to a stronger attachment with the role model, increasing the role model's effectiveness in reducing implicit gender-science biases. Associating successful women role models in STEM with one's own possible selves has the potential to affect individuals regardless of gender. As a result, women role models set the example that women can succeed in STEM (Bagès et al., 2016). Individuals may see that being successful in STEM has more to do with a person's qualities than with their gender, which could result in lower implicit gender-science bias.

The current study attempted to identify characteristics of a role model that most strongly influenced implicit gender-science bias, moderated by beliefs about one's science possible selves. However, the abilities an individual believes they possess can limit the benefits received from having a successful woman role model. If an individual believes that they do not have the intelligence and ability to mimic the role model's behaviors, they may feel like their science possible selves cannot be achieved and, thus, may feel animosity toward the role model (Bagès et al., 2016).

Drawbacks of role models. Role models may also have negative effects on individuals with strong possible selves. Individuals look toward their role model's behaviors as roadmaps for reaching their future goals, usually following similar steps to reach similar achievements. If a role model's achievements seem unattainable, the individual may feel like they can never reach their desired goals and have the same success as the role model. This feeling of unattainability can create negative attitudes toward the role model, and such negative feelings can lead to inadequate performance, disinterest in the role model's subject of study, and higher attrition within the mentee's chosen field (Lesko & Corpus, 2006). These feelings can arise when role models are perceived as gifted, easily achieving their success because of their innate, natural abilities and intelligence, rather than through hard work and effort. Individuals may then see themselves as inferior to their role models because they do not have the same innate intelligence or skill.

Implicit intelligence theories. Implicit intelligence theories state that intelligence can be perceived as a fixed entity or as malleable (Dweck, 1975). Achievement is flatlined when one views intelligence as fixed. That is, people who endorse a fixed view of intelligence believe that everyone is born with a certain capacity for intelligence and when it is achieved, intelligence cannot be further improved. When one sees intelligence as malleable, they view intelligence as something that can be improved, which results in hard work and effort, and increases performance and achievements. Considering these implicit intelligence theories, role models either exemplify what one cannot achieve via fixed views of implicit intelligence or demonstrate what one can achieve through malleable views of implicit intelligence. The role model's perceived path to intelligence (innate or learned) may influence how effective a role model can be at reducing others' implicit gender-science bias. Greater exposure to successful hardworking women role models in STEM who portray and communicate their belief in malleable views of implicit intelligence may increase their mentee's association of success with women in STEM. Prior research has found that educators with malleable views of implicit intelligence are more beneficial and that educators with fixed views of implicit intelligence inspire more fixed views of intelligence in students and less student motivation (Canning, Muenks, Green, & Murphy, 2019; Heyder, Weidinger, Cimpian, & Steinmayr, 2020). The current study sought to understand if implicit intelligence views predict whether a woman STEM role model can reduce implicit gender-science bias using priming.

Priming

Priming is exposure to a stimulus that affects future performance by triggering concepts in long-term memory through perceptual, semantic, or conceptual methods (McNamara, 1994). Priming occurs in many cognitive tasks, including semantic categorizations, lexical decisions, and item recognition, and it can reflect either conscious or unconscious processes (McNamara, 1992). The most common form of priming in role model research is affective priming, where an initial subliminal stimulus affects perceptions of subsequent stimuli by creating a stronger association between new stimuli and the prime (Blair, Ma, & Lenton, 2001). This form of priming is a result of semantic priming where one category of stimuli can elicit similar responses to another category of stimuli (McNamara, 1994). For example, exposure to physically strong Amazonian women increases the unconscious association that women are strong (Blair et al., 2001).

Repeated exposure to a prime and the retrieval process for that information affects future performance (McNamara, 1994). Exposure strengthens associations by pruning superfluous neuron connections to achieve higher selective activation of cognitive areas in the brain (Moldakarimov, Bazhenov, & Sejnowski, 2010). In daily life, individuals are continuously primed by exposure to stereotypes. This unconscious exposure often strengthens an association of a minority group (e.g., women) with an undesirable trait, for example, that women are dependent and therefore do not possess characteristics needed to be successful in STEM (e.g., independence).

Given the malleability of implicit bias, affective priming can influence an individual's biases (Fazio & Olson, 2003; Gawronski & Bodenhausen, 2006). As a minority group in STEM, women are often at a disadvantage due to implicit beliefs that men are superior. Exposure to women role models in STEM could prime individuals and promote the belief that women are just as capable of success in STEM as men. It is important, then, to determine whether the presence, or priming, of women role models in STEM can result in lower implicit gender-science bias and develop and strengthen the association of positive traits (e.g., competence) with women in STEM. This study aimed to prime individuals with a successful woman scientist role model to combat gender stereotypes and subsequently reduce implicit gender-science bias.

Assessing Implicit Bias

Implicit Association Test. Several methods can be used to measure implicit biases. The most common is the Implicit Association Test (IAT), which measures the strength of associations between an attitude object and a concept to assess implicit stereotypes. The task instructs participants to assign stimuli (e.g., words or images) to contrasting concepts (e.g., science and liberal arts) paired with an attitude object (e.g., male and female) as quickly and as accurately as possible (Gawronski, 2002; Greenwald, McGhee, & Schwartz, 1998; Nosek, Banaji, & Greenwald, 2002). Stimuli are sorted into contrasting concept categories (e.g., science and liberal arts) using two computer keys (e.g., *e* for science and *i* for liberal arts). Next, participants sort stimuli reflecting the attitude object (e.g., male or female names) into the appropriate categories (e.g., *e* for male and *i* for female). The concepts and attitude objects are then combined, where all attitude/concept pairs are assigned to the same key (e.g., *e* for male or science and *i* for female or liberal arts; see Appendix). This is an example of a stereotype congruent pairing and people with implicit gender-science bias will be faster and more accurate at categorizing stimuli when “male” is paired with “science” and “female” is paired with “liberal arts”. The second part of the combined trials uses stereotype incongruent pairing (e.g., *e* for male or liberal art words and *i* for female or science words). In these incongruent trials, or when “male” words are categorized using the same key as “liberal arts” words and “female” words are categorized using the same key as “science” words (e.g., *e* for male or literature and *i* for female or physics), people with implicit gender-science biases will have longer response times and make more errors.

An individual’s D score, or the difference between response latencies of stereotype congruent and incongruent trials, is an individual's predisposition to favor specific pairings, interpreted as implicit bias. Implicit bias D scores range from -2 to +2 (Sriram, Greenwald, & Nosek, 2010; Nosek & Sriram, 2007) . When presented with incongruent stimuli (e.g., woman and chemistry), one who has an association with stereotypical gender roles will have shorter response latencies to the stereotypical trials compared to counter-stereotypical trials, more errors on incongruent trials, and have a stronger, positive D score. The incongruence of counter-stereotypical ideas is less strongly associated in memory and requires additional inhibitory processes to override automatic responses, making them less accessible, thus increasing one’s D score. When presented with incongruent stimuli (e.g., women and chemistry), one who has a strong association with counter-stereotypical gender roles will have faster response times and greater accuracy for incongruent stimuli and weaker positive D scores, or negative D scores. In this instance, the incongruence of counter-stereotypical ideas is more strongly associated in memory, reflected in automatic responses, making them more easily accessible (Hehman, Volpert, & Simons, 2013), thus decreasing one's D score.

Although the IAT is a widely used measure of implicit bias, it has limitations, and additional methods can be used to provide convergent validity. For example, electroencephalography (EEG) can be used to examine event-related potentials (ERPs) related to implicit cognitive processes. ERPs are electrical signals in the brain stimulated by a specific sensory, motor, or cognitive event, reflecting the sum of activity from postsynaptic potentials of pyramidal neurons (Sur & Sinha, 2009). ERPs can be divided into components that can be separately analyzed to understand how individuals respond to specific stimuli. ERP components, particularly the N400 and N200, can provide convergent validity and supplement the IAT, which can make novel contributions to understanding the effects of role models on implicit gender-science bias.

N400. The N400 is an ERP component associated with implicit bias through the strength of reactions to novel stimuli. The N400 is a stimulus-locked component characterized by a sharp, negative voltage deflection occurring at the central-parietal regions of the scalp around 300-600 milliseconds after stimulus onset (Ferguson, Cane, Douchkov, & Wright, 2015). Higher amplitudes of the N400 represent greater stimulus novelty. If perceivers demonstrate greater N400 amplitudes when exposed to stimuli that pair female words with science words, compared to female words with liberal arts, this reflects novelty and indicates greater stereotypical preferences.

N200. The N200 is another ERP component associated with implicit bias through the strength of conflict monitoring reactions to incongruent trials. The N200 is a stimulus-locked component characterized by a sharp, negative voltage deflection occurring at the central and frontal regions of the scalp approximately 200 milliseconds after the onset of a stimulus (e.g., female and physics; Healy, Boran, & Smeaton, 2015). Higher amplitudes of the N200 reflect greater conflict towards incongruent stimuli (Healy et al., 2015). If perceivers demonstrate greater N200 amplitudes when exposed to stimuli that pair female words with science words, compared to female words with liberal arts, this reflects greater conflict when processing counter-stereotypical stimuli and indicates stronger stereotypical preferences. Using the N400 and the N200 ERPs in addition to the gender-science IAT provides methodological triangulation and therefore a fuller understanding of the influence role models have on implicit gender-science biases.

The Present Study

The current study examined which qualities of the role model (hardworking, gifted) have the greatest influence on implicit gender-science bias. The study also used ERP data during the gender-science IAT as measures of implicit bias to investigate the influence role model priming has on implicit gender-science biases. While we expected implicit biases to be lower for all participants who were exposed to a gifted or hardworking role model, we predicted that those who were exposed to a hardworking role model would show the lowest implicit gender-science bias compared to those who were exposed to a gifted role model. Individual differences (e.g., science possible selves and implicit intelligence theories) were also examined to understand how they moderate the relationship between the role model's characteristics (hardworking, gifted) and implicit gender-science bias.

Hypothesis 1. Participants primed with a hardworking woman role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model.

Hypothesis 2. Participants primed with a hardworking woman role model would have smaller differences in a) stimulus novelty (N400) and b) conflict monitoring (N200), between incongruent and congruent trials of the IAT compared to participants primed with a gifted role model, suggesting weaker stereotypical preferences.

Hypothesis 3. Participants primed with a hardworking woman role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model, and this relationship will be moderated by science possible selves. Specifically, participants who have stronger science possible selves would have significantly lower implicit gender-science biases (D score) after exposure to a hardworking role model than individuals who had weaker science possible selves, and those exposed to a gifted role model.

Hypothesis 4. Participants primed with a hardworking woman role model would have smaller differences in a) stimulus novelty (N400) and b) conflict monitoring (N200), between incongruent and congruent trials of the IAT compared to participants who were primed with a gifted woman role model, and this relationship will be moderated by science possible selves. Specifically, participants who had stronger science possible selves would have significantly smaller differences in a) N400 and b) N200 amplitudes between incongruent and congruent trials, suggesting weaker stereotypical preferences, after exposure to a hardworking role model than individuals who had weaker science possible selves, and those exposed to a gifted role model.

Hypothesis 5. Participants primed with a hardworking woman scientist role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by implicit intelligence theories. Specifically, participants who endorse more malleable views of implicit intelligence would have significantly lower implicit gender-science biases (D score), after exposure to a hardworking role model than individuals who had more fixed views of implicit intelligence, and those exposed to a gifted role model.

Hypothesis 6. Participants primed with a hardworking woman role model would have smaller differences in a) stimulus novelty (N400) and b) conflict monitoring (N200), between incongruent and congruent trials of the IAT compared to compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by implicit intelligence theories. Specifically, participants who endorse more malleable views implicit intelligence would have significantly smaller differences in a) N400 and b) N200 amplitudes between incongruent and congruent trials, suggesting weaker stereotypical preferences, after exposure to a hardworking role model than individuals who endorsed more fixed views of implicit intelligence and those exposed to a gifted role model, suggesting weaker stereotypical preferences.

Method

Participants

Participants were recruited from the University of Missouri-St. Louis through flyers, emails, classroom recruitment, and the Department of Psychological Sciences Sona System (Bethesda, Maryland). Research Match (Nashville, Tennessee) was also used to reach participants within the St. Louis area. Participants were compensated with 2.5 Sona credits or $20 for completion of the online questionnaire, IAT, and the experiment.

Participants (N = 42) included individuals from psychology, biology, and other STEM majors, all non-STEM majors were excluded because they are unlikely to relate to a scientist role model or have science possible selves. Additionally, inclusion criteria required participants to be between 18 to 40 years of age, right-handed, with no history of traumatic brain injury, neurological disorders, or taking any psychotropic medications. Left-handed individuals were excluded due to the potential neurological differences between left-handed and right-handed people (Willems, Haegen, Fisher, & Francks, 2014). Due to changes in brain activity caused by aging, participants who were 41 years or older were excluded from the study. Because of the influences of psychotropic drugs on brain activity, individuals taking any psychotropic medications were excluded.

Due to participant attrition, 66 participants completed the online questionnaire and IAT, while only 41 of those participants completed the online questionnaire, IAT, and experiment. The final sample (N = 41, 62% retention) reflected the demographics of UMSL and the Department of Psychological Sciences. The participants were mostly women (63%) between the ages of 18-39 (M = 23.61, SD = 4.53). Participants were 51% White, 17% African American, 10% multiracial, 7.4% Asian, 7.3% Latinx, and 7.3%

Middle Eastern. Additionally, participants were 44% psychology majors, 22% biology majors, 17% engineering majors, 12% math majors, and 5% chemistry majors.

Design

This study was a 2 X continuous between-subjects design with the first factor manipulated between subjects (role model: hardworking or gifted) and the second factor, quasi-independent variables (possible science selves, implicit intelligence theories) that were assessed continuously but analyzed at lower (-1 SD), moderate (mean), and higher (+1 SD) values to test for simple effects. A power analysis indicated 60 participants were needed to detect interaction effects if there was a medium effect size, .5.

Measures

Science possible selves. Items in the science possible selves scale are based on the possible selves as defined by Markus and Nurius (1986). The science possible selves scale was designed to evaluate the participant's image as a future scientist on a 6-point Likert scale ranging from 1 (*not at all confident*) to 6 (*very confident*). A sample item includes, "I will graduate with a college degree in the major needed for a science-related career." Higher scores indicate more positive science-related possible selves (Stake & Mares, 2001). Overall, this scale displayed good internal reliability, Cronbach's $\alpha = .935$.

Implicit intelligence theories. The 8-item Implicit Theories of Intelligence Scale (Dweck, 1975) was used to measure participants' implicit intelligence theories, with items rated from 1 (*very strongly disagree*) to 6 (*very strongly agree*). The scale assessed the general beliefs about the fixed and malleable nature of intelligence. Four fixed items were reverse-scored, and all eight items were averaged. Higher scores indicate greater belief that intelligence is malleable. Overall, this scale displayed good internal reliability, Cronbach's $\alpha = .927$.

Gender-science bias. A gender-science word IAT was used as a measure of implicit gender-science bias. The IAT used a procedure adapted from Greenwald et al. (1998). The categories were "male" and "female," and the attributes were "science" and "liberal arts," a common method to assess implicit gender-science bias (Nosek et al., 2012). Stimuli included liberal arts and science words, in addition to male and female words. Congruent trials required participants to pair “liberal arts” words with “female” words while pairing “science” words with “male” words (see Appendix). In incongruent trials, these pairings were switched. The order of the congruent and incongruent pairs was counterbalanced and randomly assigned for each participant.

The task contained training and test blocks, totaling 180 trials presented in 7 blocks. Training blocks (blocks 1, 2, 5, 6) consisted of 20 trials each, and test blocks (blocks 4 and 7) consisted of 40 trials each (Van Nunspeet, Ellemers, Derks, & Nieuwenhuis, 2012). Each trial presented a jittered fixation cross (400-600 ms), a stimulus (3000 ms), and feedback that was presented immediately after a response and stayed on the screen throughout the duration of the stimulus. Feedback was displayed as a red “X” for incorrect answers and a green “✓” for correct answers. A blank screen was presented for 1000 milliseconds at the end of each trial. Trials where participants did not respond in the 3000-millisecond response window were excluded from analyses. While participants were not notified that the training blocks were indeed only used for training, only scores for the test blocks of the gender-science IAT were used to calculate D scores using the D score algorithm developed by Greenwald, Nosek, and Banaji (2003), which accounts for excessive errors and response latency. D scores were calculated by taking the average response latency per participant and dividing each score by pooled standard deviation for each test block. Scores of each block were then averaged (Greenwald et al., 2003). Implicit bias D scores range from -2 to +2 (Sriram et al., 2010; Nosek & Sriram, 2007). An individual who has a greater association with stereotypical gender roles will have slower response latencies to the counter-stereotypical trials compared to stereotypical trials, will have more errors on counter-stereotypical pairings, and will have a stronger, positive D score. An individual who has a greater association with counter-stereotypical gender roles will have faster response latencies to the counter-stereotypical trials compared to stereotypical trials, will have fewer errors on counter-stereotypical pairings, and will have a stronger, negative D score.

Attention checks. Three free-response questions were used to assess participant attention to the role model manipulation. The questions inquired where the role model worked, what colleges the role model attended, and what game the role model played when she was a child (see Appendix). The correct answers to the free-response questions were identical for each condition (hardworking, gifted). Participants who accurately answered the two single response attention checks and included at least one correct answer to the multiple response attention check (i.e., colleges attended) were included in the analyses. No participants were excluded using this criterion.

Manipulation check. One multiple-choice question was used to assess the role model manipulation's success at depicting hardworking or gifted qualities. The question inquired which statement most accurately described the role model, using hardworking or gifted language (see Appendix). The correct answer to the manipulation check question differed for each condition (hardworking, gifted). Participants who accurately answered the manipulation check were included in the analyses. No participants were excluded using this criterion.

Perceptions of the role model. Six questions were used to assess participants' perceptions of the role model, with items rated from 1 (*very strongly disagree*) to 6 (*very strongly agree*). The questions inquired whether the role model was perceived as being inspiring and similar to the participant, and whether the role model's success seemed attainable. The inspiring perception addressed the ability of the role model to motivate the participant to achieve similar achievements. The similarity perception addressed the resemblance the participant felt between themself and the role model. Lastly, the attainability perception addressed how capable the participant believed they were in obtaining the same success as the role model. Two items each represented the inspiring, similarity, and attainability perceptions (see Appendix). All inspiring items, $r(39) = .461$, $p = .002$, similarity items, $r(39) = .383$, $p = .014$, and attainability items, $r(39) = .483$, $p = .006$, correlated with their respective pair. Items for each perception were averaged. Higher scores indicate more positive perceptions of the role model.

Electrophysiological recording. BioSemi's 16-channel acquisition software (ActiveTwo System, BioSemi, Amsterdam, The Netherlands) and amplifier were used to acquire EEG recordings. Using a nylon electrode cap, sixteen Ag/AgCl active electrodes were placed on the participant's scalp (O1, Oz, O2, P3, Pz, P4, T7, T8, C3, Cz, C4, F3, Fz, F4, Fp1, Fp2). Two electrodes were attached to the left and right mastoids (M1/2) and vertical electrooculogram (VEOG) and horizontal electrooculogram (HEOG; UltraFlat active electrodes, BioSemi) were attached below the left eye and outside of the right eye.

All voltages were digitized with a sample rate of 512 Hz and recorded relative to a common mode voltage derived from the ActiveTwo's common mode sense/driven right leg feedback loop.

ERP measures. Differences in amplitudes of a) N400 and b) N200 were used to assess novelty and conflict monitoring, respectively. N400 difference scores were computed by subtracting the N400 amplitudes for congruent trials from incongruent trials. Due to the negative amplitude of the N400, negative difference scores denote stronger novelty towards incongruent stimuli (e.g., women and science) compared to congruent stimuli (e.g., men and science). This greater novelty towards incongruent stimuli indicates a weaker association between women and science, suggesting stronger stereotypical preferences. More positive difference scores denote a stronger novelty towards congruent stimuli (e.g., men and science) compared to incongruent stimuli (e.g., women and science). This novelty toward congruent stimuli, as opposed to incongruent stimuli, indicates stronger associations between women and science, suggesting stronger counter-stereotypical preferences. Therefore, a larger, negative difference score suggests stronger stereotypical preferences, while a smaller, negative difference score suggests weaker stereotypical preferences. Additionally, a larger, positive difference score suggests stronger counter-stereotypical preferences, while a smaller, positive difference score suggests weaker counter-stereotypical preferences. No or little significant difference between congruent and incongruent trials indicates no difference in novelty between congruent and incongruent trials, signifying little to no stereotypical or counter-stereotypical preferences.

N200 amplitude difference scores were similarly computed, where N200 amplitudes for congruent trials were subtracted from incongruent trials. Due to the negative amplitude of the N200, negative difference scores denote greater conflict when processing incongruent stimuli (e.g., women and science) compared to congruent stimuli (e.g., men and science). This greater conflict monitoring towards incongruent stimuli indicates a weaker association between women and science, suggesting greater stereotypical preferences. More positive difference scores denote greater conflict when monitoring congruent stimuli (e.g., men and science) compared to incongruent stimuli (e.g., women and science). This greater conflict monitoring toward congruent stimuli, as opposed to incongruent stimuli, indicates a stronger association between women and science, suggesting stronger counter-stereotypical preferences. Therefore, a larger, negative difference score suggests stronger stereotypical preferences, while a smaller, negative difference score suggest weaker stereotypical preferences. Additionally, a larger, positive difference score suggests stronger counter-stereotypical preferences, while a smaller, positive difference score suggests weaker counter-stereotypical preferences. No or little significant difference between congruent and incongruent trials indicates no difference in conflict processing between congruent and incongruent trials, signifying little to no stereotypical or counter-stereotypical preferences.

Procedure

Online questionnaire. Before participating in the experiment, participants completed online self-report measures, hosted by Qualtrics (Provo, Utah), to determine eligibility. Once participants completed the eligibility questionnaire (see Appendix), they were directed to the online questionnaire, hosted by Qualtrics, in which they reported individual differences of science possible selves and implicit intelligence theories (see Appendix). Once finished, participants were directed to the gender-science IAT, hosted by Millisecond using Inquisit Web 5.0 software (Inquisit 5 Lab, Millisecond Software, Seattle, WA, USA). After completion of the IAT, the participants were directed to a Doodle poll where they indicated their availability for completing the experimental portion of the study. Participants were then contacted and were schedule for the experimental session.

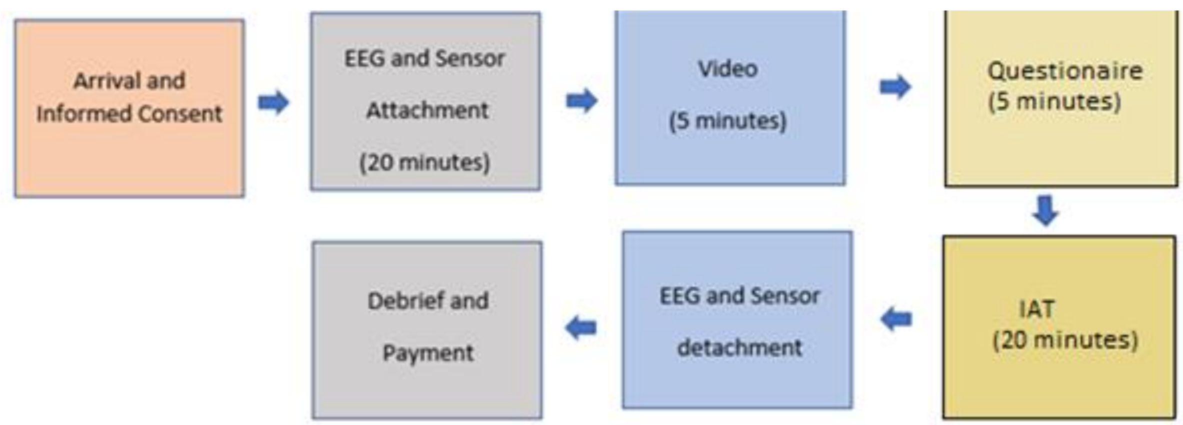
Experiment. When participants arrived at the lab, they completed an informed consent form. Once informed consent had been obtained, an EEG cap and sensors were connected to the participant to record eye movements and blinks, and electrophysiological activity during the IAT.

***Manipulation*.** After setup, participants watched a 5-minute video featuring a documentary style video of a successful woman scientist role model. Participants were randomly assigned to watch one of two video clips portraying the role model as hardworking or as gifted. The videos included a voice-over of the woman's work life, her childhood to demonstrate her abilities, and her current accomplishments. The content of the two videos was identical except the language used in the voice-over was manipulated to present the role model’s qualities (hardworking, gifted; see Appendix).

Once the participants viewed the 5-minute video, they were asked to complete self-report measures in which they answered questions about the video, noted their perceptions of the role model, and reported their science possible selves and implicit intelligence theories. After completion of the self-report measures, participants took the gender-science IAT, identical to the one they completed online before the experiment session.

Post-manipulation. At the completion of the IAT, participants were unhooked from the EEG and facial sensors. The researcher debriefed the participant and granted compensation. The entire procedure took 50 minutes (see Figure 1).

Figure 1. Experiment Timeline



Data Preparation

All scalp electrodes were referenced to an averaged mastoid reference. VEOG and HEOG signals were used to correct for ocular artifacts via Independent Component Analysis (ICA; Makeig, Bell, Jung, & Sejnowski, 1996) using BrainVision Analyzer 2 (Brain Vision LLC; Morrisville, NC). Segments were rejected based on a maximum allowed voltage gradient of 50 µV and a maximum absolute difference threshold of 75 µV (Hehman et al., 2013). ERP data were filtered offline with a 0.01-30 bandpass filter and a 60 Hz notch filter (Hehman et al., 2013). The data was then segmented into 1s epochs after the onset of each stimulus using BrainVision Analyzer 2 (Brain Vision LLC; Morrisville, NC). All segments were baseline-corrected by subtracting the average voltage during the 100ms before stimulus presentation.

ERPs were averaged based on stimuli (incongruent, congruent) within each participant. Peaks of the averaged waveforms were then labeled on all scalp locations for amplitudes within respective time windows for the N400 (300-500ms after stimuli; Ferguson et al., 2014) and N200 (100-300ms after the stimuli; Graham et al., 2015). N400 amplitudes were assessed at the parietal midline electrode (i.e., Pz) and N200 amplitudes were assessed at the frontal midline electrode (i.e., Fz; Kopp et al., 1996).

All data were screened for multivariate outliers using Mahalanobis' Distance (Howell, 2013); no multivariate outliers were found. All data were screened for accuracy on attention and manipulation checks. Participants who accurately answered the manipulation check were included in the analyses. Additionally, participants who correctly answered the two single response attention checks and listed at least one correct answer to the multiple response attention check were included in the analyses (see Appendix). No participants were excluded using this criterion. Assumptions of normality, residuals, linearity, and homoscedasticity for regression were met.

Prior research has shown that being similar, inspiring, and having attainable success are essential characteristics for influential role models (Lockwood & Kunda, 1997; Rosenthal et al., 2013), thus, differences in role model perceptions were analyzed. No significant differences in the inspiring and similarity perceptions were found based on gender, major, age, or race. Significant gender differences in the attainability perception were found, showing that women (M = 4.049, SD = .761) were more confident they could achieve the same success as the role model compared to men (M = 3.433, SD = .821), $t(39) = -2.383$, $p = .022$, $d = .783$). No significant differences on the attainability perception were found based on major, age, or race. Additional analyses were conducted to assess if differences in each role model perception (i.e., inspiring, similarity, and attainability) affected implicit gender-science bias (D score, N400, N200), the study's outcome variables. No significant differences in implicit gender-science bias (D score, N400, N200) were found among any of the role model perceptions. Therefore, none of the role model perceptions were used as covariates for the current study's analyses.

General linear modeling with repeated measures was used to test the relationship between role model conditions on changes in implicit bias (D score). Additionally, the PROCESS macro for SPSS 25 (model 1; Hayes, 2012) was used to test for moderating effects of individual differences (science possible selves, implicit intelligence theories) on implicit bias (D score, N400, N200) between role model conditions. All simple slopes for significant or trending results are graphed at +1, mean, and -1 standard deviations. Role model condition was entered as a dichotomous independent variable and individual difference variables (science possible selves, implicit intelligence theories) were individually entered as continuous moderators of differences in implicit bias (D scores, N400, N200) between role model conditions. Age, gender, race, and major were all analyzed for differences in the outcome variables. Age showed a significant difference in implicit gender-science bias (D score), $F(1, 39) = 6.771$, $p = .013$, $b = -.039$, $\Delta R^2 = .148$, where older participants showed stronger preferences for counter-stereotypical stimuli compared to younger participants. Major showed a significant difference in implicit gender-science bias (D scores), $F(4, 36) = 2.737$, $p = .044$, $\eta^2 = .232$. Post hoc comparisons using the Tukey HSD test indicated that chemistry majors ($M = .804$, $SD = .044$) had significantly higher implicit gender-science bias compared to math majors ($M = -.281$, $SD = .147$). No other differences between majors were found. Race showed significant differences in N200 amplitudes $F(5, 35) = 3.558$, $p = .010$, $\eta^2 = .270$. Post hoc comparisons using the Tukey HSD test indicated that Middle Eastern participants (M = - 1.174, SD = 1.463) had stronger electrophysiological indices of implicit gender-science bias compared to Asian (M = .159, SD = .454), African American (M = -.033, SD = .199), White (M = .028, SD = .183), Latinx (M = .827, SD =.766), and Multiracial (M = -.115, SD = .617) participants. No other differences were found between racial groups. As stated previously, no significant differences in implicit gender-science bias were found among any of the role model perception variables (i.e., inspiring, similarity, and attainability). Due to the differences described previously, all general linear modeling with repeated measures analyses with task implicit bias (D score) controlled for age and major. All moderation analyses with task-based implicit bias (D score) analyses controlled for age, major and baseline implicit bias, while using post-manipulation implicit bias for the dependent variable. All ERP analyses controlled for race and age.

Results

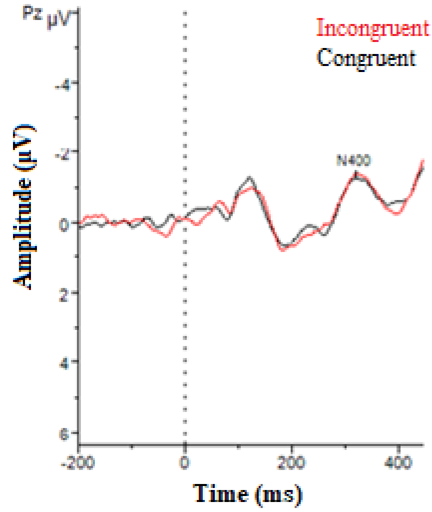
Hypothesis Testing

To test Hypothesis 1, general linear modeling with repeated measures was conducted to analyze the relationship between role model condition and implicit gender-science bias (D score). These analyses were computed to investigate if differences in role model quality (hardworking or gifted) predicted changes in implicit gender-science bias when controlling for major and age. Hypothesis 1 stated participants primed with a hardworking woman role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model. Results showed that the main effect of role model condition on implicit bias (D score) after the manipulation was not significant, $F(1, 37) = .677$, $p = .418$, $\eta^2_p = .103$, contrary to Hypothesis 1. Implicit bias did not decrease from baseline after role model exposure for participants in either condition, $F(1, 39) = .669$, $p = .418$, $\eta^2_p = .017$.

To test Hypothesis 2, linear regressions were conducted to investigate if differences in role model quality (hardworking, gifted) predicted electrophysiological indices of implicit gender-science bias when controlling for race and age. Hypothesis 2 stated that participants primed with a hardworking woman role model would have lower a) stimulus novelty (N400) and b) conflict monitoring (N200) compared to participants who were primed with a gifted role model.

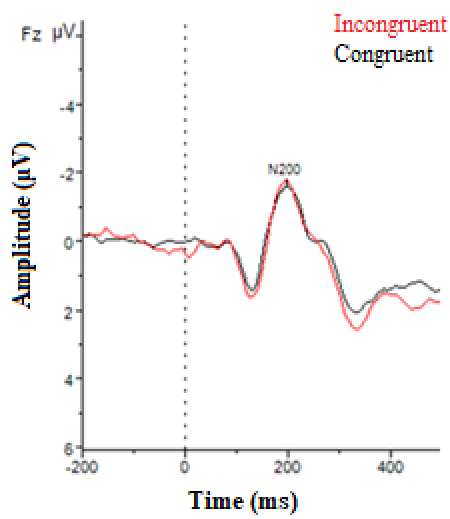
No significant differences in N400 amplitudes were found between incongruent and congruent trials of the IAT, $t(40) = 1.582$, $p = .122$, $d = .317$. Furthermore, no significant differences in N200 amplitudes were found between incongruent and congruent trials of the IAT, $t(40) = 1.764$, $p = .172$, $d = .267$. Given that no significant differences in ERP amplitudes were found between incongruent and congruent trials of the IAT, the ability to test hypotheses involving ERPs may be affected. The main effect of role model condition on N400 amplitude difference scores, electrophysiological indices of novelty, was not significant, $F(3, 37) = .779$, $p = .513$, $b = -1.084$, $\Delta R^2 = .059$. Additionally, the main effect of role model condition on N200 amplitude difference scores, electrophysiological indices of conflict monitoring, was not significant, $F(3, 37) = .810$, $p = .496$, $b = .472$, $\Delta R^2 = .062$, contrary to Hypothesis 2.

Figure 2. N400 Amplitudes During Incongruent and Congruent Trials of the Gender-Science IAT.



Notes. Averaged stimulus-locked N400 amplitude at the Fz electrode for incongruent and congruent gender-science IAT trials. Zero represents time of stimuli onset. The N400 is the negative most amplitude peaking at approximately 400 ms.

Figure 3. N200 Amplitudes During Incongruent and Congruent Trials of the Gender-Science IAT.



Notes. Averaged stimulus-locked N200 amplitude at Fz electrode for incongruent and congruent gender-science IAT trials. Zero represents time of stimulus onset. The N200 is the negative most amplitude peaking at approximately 200ms.

To test Hypotheses 3 and 4, multiple regressions were conducted to analyze the moderating effect of science possible selves on the relationship between role model condition and implicit gender-science bias (D score, N200, N400). Hypothesis 3 stated that participants primed with a hardworking woman role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by science possible selves. Specifically, participants who had stronger science possible selves would have significantly lower implicit gender-science biases (D score) after exposure to a hardworking role model than individuals who had weaker science possible selves, and those exposed to a gifted role model. Hypothesis 4 stated that participants primed with a hardworking woman role model would have lower a) stimulus novelty (N400) and b) conflict monitoring (N200) compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by science possible selves. Specifically, participants who had stronger science possible selves would have significantly smaller differences in a) N400 and b) N200 amplitudes between incongruent and congruent trials after being exposed to a hardworking role model than individuals who had weaker science possible selves, and those exposed to a gifted role model.

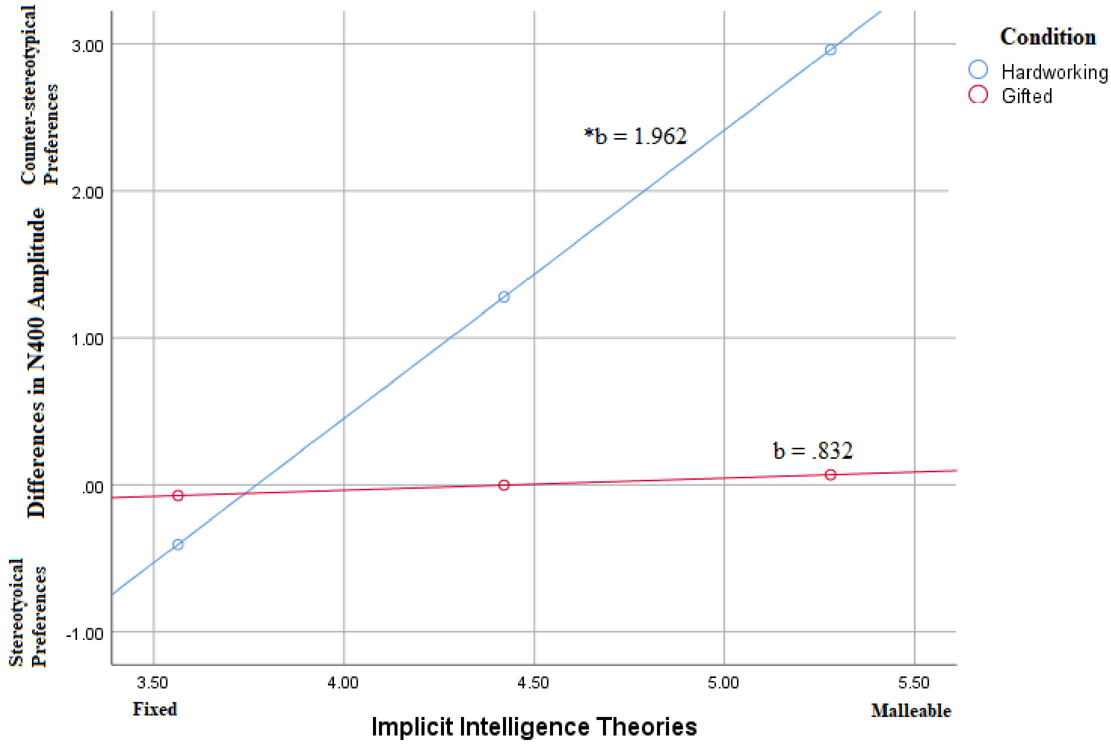
Results showed the interaction between role model condition and science possible selves was not significant for implicit gender-science bias (D score), $F(6, 34) = 1.648$, $p = .166$, $b = .496$, $\Delta R^2 = .225$, when controlling for major, age, and baseline implicit gender-science bias, contrary to Hypothesis 3. Additionally, the interaction between role model condition and science possible selves was not significant for N400 amplitude difference scores, $F(5, 35) = .670$, $p = .656$, $b = -.529$, $\Delta R^2 = .086$, or for N200 amplitude difference scores, $F(5, 35) = 1.011$, $p = .422$, $b = 1.192$, $\Delta R^2 = .127$, contrary to Hypothesis 4.

To test Hypotheses 5 and 6, multiple regressions were conducted to analyze the moderating effects of implicit intelligence theories on the relationship between role model condition and implicit gender-science bias (D score, N200, N400). Hypothesis 5 stated that participants primed with a hardworking woman role model would have lower implicit gender-science bias (D score) after the role model manipulation, compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by implicit intelligence theories when controlling for major, age, and baseline implicit gender-science bias. Specifically, participants who endorse more malleable views of implicit intelligence would have significantly lower implicit gender-science biases (D score) after being exposed to a hardworking role model than individuals who had more fixed views of implicit intelligence, and those who were exposed to a gifted role model.

Hypothesis 6 stated that participants primed with a hardworking woman role model would have lower a) stimulus novelty (N400) and b) conflict monitoring (N200) compared to participants who were primed with a gifted woman role model, and this relationship would be moderated by implicit intelligence theories, when controlling for race and age. Specifically, participants who had more malleable views of implicit intelligence would have significantly smaller differences in a) N400 and b) N200 amplitudes between incongruent and congruent trials after exposure to a hardworking role model than individuals who had more fixed views of implicit intelligence and those exposed to a gifted role model. Results showed the interaction between role model condition and implicit intelligence theories was not significant for implicit gender-science bias scores (D score), $F(3, 35) = 1.170$, $p = .343$, $b = -.318$, $\Delta R^2 = .143$, contrary to Hypothesis 5.

The interaction between role model condition and implicit intelligence theories was trending towards significance in predicting N400 amplitudes, $F(5, 35) = 1.651$, $p = .173$, $b = -1.592$, $p = .119$, $\Delta R^2 = .191$. Conditional effects revealed that participants with more malleable views of implicit intelligence, who were exposed to a hardworking role model experienced less novelty looking at stereotype incongruent (e.g., women and science) pairs compared to stereotype congruent (e.g., women and liberal arts) pairs, as indicated by more positive N400 amplitude difference scores, demonstrating stronger counter-stereotypical preferences, ($b = 1.873$, $SE = .807$, $p = .026$, $\Delta R^2 = .059$), compared to individuals with more fixed views of implicit intelligence (see Figure 2). No significant relationship between implicit intelligence and N400 amplitude difference scores was found among those exposed to a gifted role model, ($b = .286$, $SE = .564$, $p = .616$, $\Delta R^2 = .059$; see Figure 2), contrary to Hypothesis 6. The interaction between role model condition and implicit intelligence theories was not significant in predicting N200 amplitude difference scores, $F(3, 35) = .565$, $p = .726$, $b = .508$, $\Delta R^2 = .075$, contrary to Hypothesis 6.

Figure 4. The Effect of Role Model Condition and Implicit Intelligence Theories on N400 Amplitude.



Notes. Interaction between role model condition and implicit intelligence theories predicting novelty, as indicated by N400 amplitude difference scores, controlling for age and major. Higher, positive values on the y-axis indicate stronger counter-stereotypical preferences, associating women and science more strongly than men and science. Lower, more negative values on the y-axis indicate stronger stereotypical preferences, associating men and science more strongly than women and science. Higher values on the x-axis indicate more malleable views of implicit intelligence. Lower values on the x-axis indicate more fixed views of implicit intelligence. $*p < 0.05$.

Exploratory Analyses

Given that the hypotheses of the current study were not supported, exploratory analyses were conducted to evaluate if other factors (i.e., role model perceptions) moderate the relationship between role model condition and implicit gender-science bias, if role model condition can predicts other factors (i.e., individual difference), or if other factors (i.e., individual differences) predict baseline implicit gender-science bias.

Perceptions of the Role Model. Multiple regressions were computed to investigate whether perceptions of the role model (i.e., inspiring, similarity, and attainability) moderate the relationship between role model condition and implicit gender-science bias (D score, N400, N200). The interaction between role model condition and the inspiring perception was not significant in predicting implicit gender-science bias (D score) when controlling for baseline implicit bias, $F(4, 36) = .405$, $p = .803$, $b = .038$, $\Delta R^2 = .043$. Additionally, the interaction between role model condition and the inspiring perception was not significant in predicting electrophysiological indices of implicit bias, measure by N400 amplitude difference scores, $F(5, 35) = .906$, $p = .489$, $b = .197$, $\Delta R^2 = .114$, or N200 amplitude difference scores, $F(5, 35) = .594$, $p = .705$, $b = .682$, $\Delta R^2 = .078$.

The interaction between role model condition and the similarity perception was not significant in predicting implicit gender-science bias (D score), when controlling for baseline implicit bias, $F(4, 36) = .404$, $p = .903$, $b = -.016$, $\Delta R^2 = .142$. Additionally, the interaction between role model condition and the similarity perception was not significant in predicting electrophysiological indices of implicit bias, measure by N400 amplitude difference scores, $F(5, 35) = 1.24$, $p = .312$, $b = -2.57$, $\Delta R^2 = .150$, or N200 amplitude difference scores, $F(5, 35) = .864$, $p = .514$, $b = 1.29$, $\Delta R^2 = .110$.

The interaction between role model condition and the attainability perception was not significant in predicting implicit gender-science bias (D score), when controlling for baseline implicit bias, $F(5, 35) = .346$, $p = .845$, $b = .308$, $\Delta R^2 = .037$. Additionally, the interaction between role model condition and the attainability perception was not significant in predicting electrophysiological indices of implicit bias, measured by N400 amplitude difference scores, $F(5, 35) = .772$, $p = .577$, $b = -1.25$, $\Delta R^2 = .099$, or N200 amplitude difference scores, $F(5, 35) = .558$, $p = .731$, $b = -.554$, $\Delta R^2 = .074$.

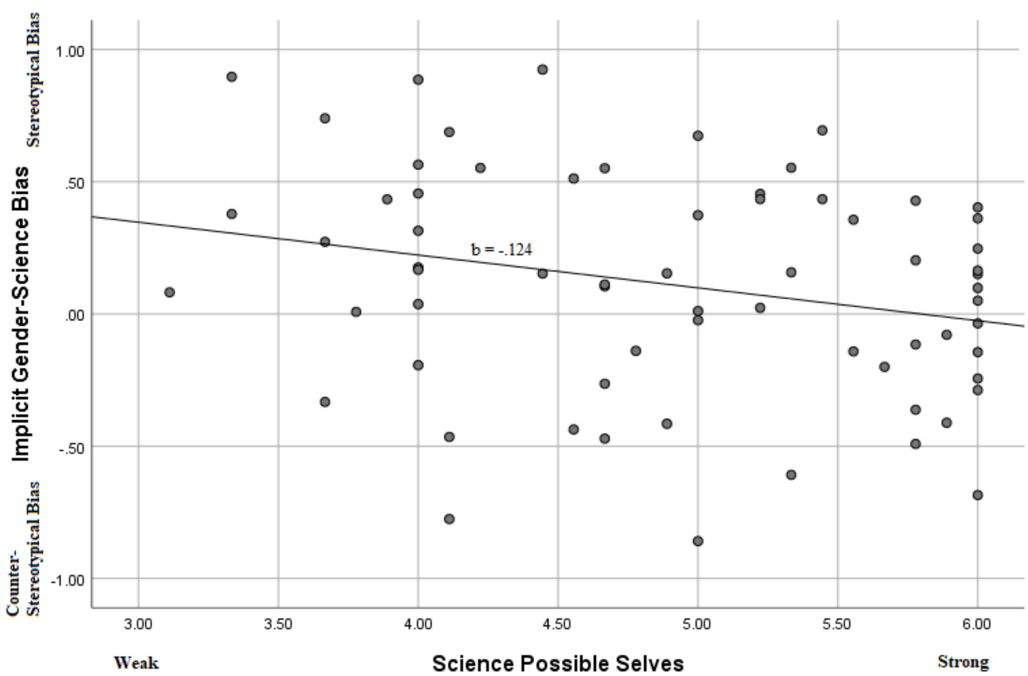
Individual Differences. Generalized linear modeling with repeated measures were analyzed to investigate whether the role model condition predicted changes in science possible selves and implicit intelligence theories after the manipulation. Age, gender, race, major, and all three role model perceptions (i.e., inspiring, similarity, and attainability) were analyzed for differences in the two outcome variables (science possible selves, implicit intelligence theories). No differences were found; thus, no covariates were used in these analyses.

To test if the role model manipulation has more influence on other factors, exploratory analyses were conducted to evaluate if the role model manipulation influences science possible selves and implicit intelligence theories. Results of a general linear modeling with repeated measures showed that the main effect of role model condition on science possible selves after the manipulation, was not significant, $F(1, 39) = .616$, $p = .437$, $\eta^2_p = .016$. Furthermore, the main effect of role model condition on implicit intelligence theories after the manipulation was not significant, $F(1, 39) = .928$, $p = .404$, $\eta^2_p = .018$.

To test if other factors besides the role model condition were more predictive of lower implicit gender-science bias, exploratory analyses were conducted to evaluate if science possible selves and implicit intelligence theories predict implicit gender-science bias (D score), using a larger sample, which included all participants ($N = 66$) who completed the online questionnaire before coming into the lab for the experiment.

Linear regressions were conducted to investigate if baseline science possible selves and implicit intelligence theories predicted baseline implicit bias (D score). Age, gender, race, and major, were analyzed for differences in implicit bias (D score) within the enlarged sample. No differences were found; thus, no covariates were used in these analyses. The main effect of baseline science possible selves on implicit bias (D score) was significant, $F(1, 65) = 4.005$, $p = .050$, $b = -.118$, $\Delta R^2 = .058$, where higher science possible selves predicted lower implicit gender science bias. However, the main effect of the initial implicit intelligence theories on implicit gender-science bias (D score) was not significant, $F(1, 65) = .344$, $p = .559$, $b = .037$, $\Delta R^2 = .005$.

Figure 5. The Relationship Between Science Possible Selves and Implicit Gender-Science Bias.



Notes. Relationship between science possible selves and implicit gender-science bias (D score). Higher, positive values on the y-axis indicate stereotypical gender-science bias associating men and science more strongly than women and science. Lower, more negative values on the y-axis indicate counter-stereotypical gender-science bias associating women and science more strongly than men and science. Higher values on the x-axis indicate stronger science possible selves. Lower values on the x-axis indicate weaker science possible selves.

Discussion

Although the hypotheses were not supported, this experiment attempted to uniquely investigate how the characteristics of a woman role model (hardworking, gifted) influenced implicit gender-science bias and attempted to examine how science possible selves and implicit intelligence theories moderated the influence role models have on implicit gender-science bias. Though not explicitly hypothesized, results showed that implicit intelligence theories may moderate the relationship between role model condition and novelty, as measured by N400 amplitudes, an electrophysiological index of implicit bias. Findings showed that participants with more malleable views of intelligence who were exposed to a hardworking role model had stronger counter-stereotypical preferences compared to participants with more fixed views of intelligence. Additionally, results from exploratory analyses indicate that science possible selves may predict implicit gender-science bias (D score). When looking at the participants who only completed the online portion of the study (N = 66), higher science possible selves predicted lower implicit gender-science bias.

Prior research indicates that women role models can lower forms of implicit bias (Dasgupta & Asgari, 2004; Young et al., 2013), yet these findings were not supported in the current study. Results showed that exposure to a hardworking woman role model, as opposed to a gifted woman role model, did not impact implicit gender-science bias (D score) or predict electrophysiological indices of implicit gender-science bias (N400, N200). These results are also inconsistent with prior studies that have found that certain role model qualities are more influential compared to other qualities, specifically, being inspiring, similar to one's mentee, and having attainable success (Dasgupta & Asgari, 2004; Young et al., 2013). The support of the null hypotheses in the current study suggest that being a hardworking or a gifted role model has no influence on implicit gender-science bias, which indicates that future research should examine other qualities of the role model that may be more impactful (e.g., familiarity). However, these null findings may be due to the limitations of the current study. Therefore, future research should attempt to replicate these findings with a manipulation that has a more impactful role model exposure, such as longitudinally, before any conclusions can be made.

Past research has used longitudinal methodology to study role models, via student-professor relationships for the entirety of a university semester (Dasgupta & Asgari, 2004; Young et al., 2013). This study's design differs from the role model manipulations that can be conducted in a lab setting. In the current study, participants were only able to see a five-minute video of an unfamiliar role model figure. Having longer exposure to a familiar role model may be more impactful, and thus, may be one of the reasons for the null findings in the current study.

When looking at individual differences of the mentee, this study found that one's science possible selves did not moderate implicit bias (D score) or predict electrophysiological indices of implicit gender-bias (N400, N200). However, exploratory analyses using participants who only completed the online portion of the study (N = 66) showed that one's science possible selves may predict baseline implicit gender-science bias (D score). These findings may indicate that one's science possible selves may not predict the effectiveness of a role model but may be predictive of implicit gender-science bias due to other unknown variables. Potentially, individuals higher in science possible selves would have more exposure to women role models or more STEM self-efficacy which may lower implicit gender-science bias, but in turn, could diminish the impression the brief role model manipulation had on the individuals.

Implicit intelligence theories' ability to moderate the relationship between role model condition and implicit gender-science bias was also tested in this study. Results showed that implicit intelligence theories may not moderate the relationship between role model exposure and task-based implicit bias (D score) or conflict monitoring, an electrophysiological index of implicit bias measured through N200 amplitudes. However, there was some support that implicit intelligence theories may moderate the relationship between role model exposure and stimuli novelty, an electrophysiological index of implicit bias measured through N400 amplitudes. Finding showed that participants who had more malleable views of implicit intelligence and who were exposed to a hardworking role model, experienced a greater difference in N400 amplitudes, between incongruent (e.g., women and science) and congruent (e.g., women and liberal arts) trials, with congruent trials having larger differences in N400 amplitudes compared to incongruent trials, suggesting stronger counter-stereotypical preferences.

While Hypothesis 6a predicted that participants with higher malleable views of implicit intelligence in the hardworking role model condition would have smaller differences in the N400, this hypothesis assumed participants would show some stereotypical preference, regardless of condition. However, results indicated that individuals with more malleable views of implicit intelligence, who were exposed to a hardworking woman role model showed more novelty towards stereotypical stimuli, indicating counter-stereotypical preferences. As a result, a greater difference in N400 would be expected. While these findings were not hypothesized *a priori*, these results fall in line with arguments given to support Hypothesis 6a, stating that participants with more malleable views of intelligence who were exposed to a hardworking role model would have stronger associations with women and science than participants with more fixed views of intelligence, or who were in the gifted condition.

This finding partially supports prior research that states role models who have attainable achievements are more effective at influencing their mentee's self-views, compared to perceived unattainable achievements (Lockwood & Kunda 1997). Sharing the same malleable mindset of implicit intelligence theories may encourage the mentee to believe that all people can achieve the same success if they put in the effort, leading to more counter-stereotypical preferences. Additionally, similar views of intelligence between the role model and the mentee may have increased how influential the role model was at lowering implicit gender-science bias, which falls in line with previous research (Rosenthal et al., 2013).

Limitations

While these results may increase our knowledge about the effect role models have on implicit gender-science bias, the limitations of this study may aid in the development of more effective methodologies for studying role model influences in a lab setting. Specifically, while the participants in this study accurately assessed the manipulated qualities of the woman role model depicted in each condition and rated the role model high on known influential role model qualities (e.g., inspiring, similarity, attainability; Lockwood & Kunda, 1997; Rosenthal et al., 2013); a five-minute video may not have been enough time to influence implicit gender-science bias. Individuals encounter many potentially bias-impactful stimuli through the day, one brief exposure to an unknown woman scientist with whom they have no relationship may not be impressionable enough to directly influence one's unconscious biases, making the manipulation ineffective. Manipulations with longer role model exposure may be more effective at lowering implicit bias. Additionally, role models may be more effective if participants are familiar with, or have a relationship with, the role model.

Further, the study's measure of implicit bias was adapted to measure task-based implicit bias (D score), while simultaneously measuring electrophysiological indices of implicit bias through ERPs. This required the IAT to be lengthened, having stimuli stay on the screen for an extended period compared to the original task designed by Greenwald and colleagues (1995). In the current study, stimuli remained on the screen for 3000ms regardless of when the participant responded. In the original gender-science IAT, stimuli were removed from the screen and a new trial began immediately after the participant's response and feedback.

Prior research has found that the D score is influenced by individual differences in response time (McFarland & Crouch, 2002) and that simple tasks have shorter average mean response times compared to complex tasks (Sriram et al., 2010). The extended time between trials on the modified IAT used in this study may have been less cognitively taxing on the individual and therefore, may have caused differences in scoring between the modified task and the original. Additionally, the constant feedback given to the participant, along with the extended time received between the feedback and the next trial may have allowed the participant to learn from their mistakes, improving their performance on later trials. As a result of these changes, this modified IAT may have inadvertently led to lower recorded implicit gender-science bias.

Implicit bias D scores range from -2 to +2 (Sriram et al., 2010; Nosek & Sriram, 2007) and past research reports that implicit gender-science bias D scores usually fall around .76 to 1.20 (Miller, Eagly, & Linn, 2015). The participants of the current study had an average implicit gender-science bias score of 0.21 which was remarkably lower than expected. Additionally, prior research included participants in all academic fields, not just STEM (Dasgupta & Asgari, 2004; Lockwood & Kunda, 1997; Rosenthal et al., 2013; Young et al., 2013). Including participants from other fields, who may not have as much exposure to STEM role models, and therefore have higher implicit gender-science bias, may have made the role model manipulation more impactful at influencing implicit gender-science bias.

Furthermore, while the study's measure of implicit bias was adapted to simultaneously measure electrophysiological indices of implicit bias through ERPs, the stimuli presented during the IAT may not have been impactful enough to influence stimuli novelty, measured by the N400, or conflict monitoring, measured by the N200. In trials of the IAT, participants sort words into gender (male, female) and science (science, liberal arts) categories. The trial is considered congruent or incongruent depending on which gender category (male or female) is paired with which science category (science or liberal arts). The trial is not determined as congruent or incongruent by the initial word that is being categorized. However, given that the initial word being categorized is presented at the center of the screen, the ERPs may be reflecting responses to the initial word and not to the complete trial. Presentation of the initial word is not considered to be congruent or incongruent on its own and would therefore not be considered novel or create any conflict. As a result, trials of the IAT may not be impactful enough stimuli to accurately assess ERP amplitudes, and consequently implicit bias.

Lastly, due to time constraints and participant attrition, the sample size for this study was below the recommended size (*N* = 60) needed to detect an interaction if we expected a medium effect size of .5. This smaller sample size decreased the study's power, and therefore, limits hypothes testing. Due to the limitations in the present study, the results are inconclusive. However, future research can consider the limitations of the methodology in this current study and make improvements to better inform effective intervention strategies.

Implications

Further research should be conducted on the impact role models can have on implicit gender-science bias. With the underrepresentation of women still being a pervasive problem in STEM fields, finding interventions to combat implicit gender-science bias could alleviate some of the negative consequences women face in STEM that lead to higher attrition rates for women. Accounting for the current study's findings and limitations, future research should investigate additional variables that could moderate the relationship between role model exposure and implicit gender-science bias.

Additionally, these results may suggest that the type of in-lab experimental method used in this study is not influential enough to have an impact on individual views. The limitations of this study may aid in the development of more effective methodologies for studying role model influences in a lab setting, such as incorporating longer exposure to a familiar role model in future research. This study and future research will aid in the development of role model interventions to specifically target implicit gender-science bias.

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Appendix

Eligibility Screening

What is your race or ethnicity?

1. Asian/Pacific Islander

2. African American/Black, Not Hispanic

3. Caucasian/White, Not Hispanic

4. Latino(a)/Chicano(a), Hispanic

5. Middle Eastern

6. Native American/Alaskan Native

7. Other

8. Multiracial

What is your sex?

1. Male

2. Female

3. Other gender not specified here

What is your age? (Free Response)

Are you right-handed?

1. Yes
2. No

Do you have a history of traumatic brain injury?

1. Yes

2. No

Have you been diagnosed with clinical anxiety in the last 6 months?

1. Yes
2. No

Have you ever been diagnosed with a neurological disorder?

1. Yes
2. No

Are you currently taking any type of anti-depressant medication (with or without a prescription;

e.g., Lexapro, Cipralex, Paxil, Seroxat, Prozac, Luvox, Zoloft, or others)?

1. No

2. Yes

What department is your actual or intended major, or chosen profession in?

1. Art
2. Mathematics
3. Business
4. Engineering and Technology
5. Literature and Language
6. Psychology
7. Education
8. Chemistry
9. Physics
10. Biology

11. Nursing

Gender-Science IAT

Adapted from:

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Harvesting implicit group attitudes and beliefs from a demonstration web site. *Group Dynamics: Theory, Research, and Practice, 6*(1), 101-115.

Science Stimuli:
Biology, Physics, Chemistry, Math, Geology, Astronomy, Engineering

Liberal Arts Stimuli:
Philosophy, Humanities, Arts, Literature, English, Music, History

Male Stimuli:
Man, Boy, Father, Male, Grandpa, Husband, Son, Uncle

Female Stimuli:
Girl, Female, Aunt, Daughter, Wife, Woman, Mother, Grandmother

(400-600 ms) (3000 ms) (1000ms)

Science Possible Selves

Adapted from:

Stake, J. E., & Mares, K. R. (2001). Science enrichment programs for gifted high school girls and boys: Predictors of program impact on science confidence and motivation. *Journal of Research in Science Teaching*, *38*, 1065–1088.

Please rate all Items from 1 *very strongly disagree* to 6 *very strongly agree.*

1. I would enjoy a career related to science.

2. I have good feelings about a career related to science.
3. Having a career related to science would be interesting.
4. I would like to have a career related science
5. I will make it into a good college and major in the area related to science
6. I will graduate with a college degree in the major needed for a science related career
7. I will get into graduate or medical school and continue my education
8. I will graduate from my graduate or medical school program.
9. I will have a strong professional career and make substantial contributions to science.

Implicit Theories of Intelligence

Adapted from:

Dweck, C. S. (1975). The role of expectations and attributions in the alleviation of learned helplessness. *Journal of Personality and Social Psychology, 31*, 674-685.

Please rate the following questions from very 1 *very strongly disagree* to 6 *very strongly agree*

1. You have a certain amount of intelligence, and you can’t really do much to change it.
2. Your intelligence is something about you that you can’t change very much.
3. To be honest, you can’t really change how intelligent you are.
4. You can learn new things, but you can’t really change your basic intelligence.

5. No matter who you are, you can significantly change your intelligence level.
6. You can always substantially change how intelligent you are.
7. No matter how much intelligence you have you can always change it quite a bit.
8. You can change even your basic intelligence level considerably.

Attention Checks

What game did Michelle Simmons play with her dad when she was little?

Where did Michelle Simmons go to school for Chemistry?

Where does Michelle Simmons currently work?

Manipulation Check

Which of the following most accurately describes Michelle Simmons?

1. Michelle Simmons had a natural understanding of chemistry which lead her to her accomplishments.
2. Michelle Simmons had to put in work and make an effort to reach her accomplishments.
3. Michelle Simmons decided she did not enjoy chemistry and decided to switch careers later in life.

Perceptions of Role Model

Thinking back to the video you just watched, please rate the following questions from 1 *very strongly disagree* to 6 *very strongly agree*.

1. Michelle Simmons and I share similarities.
2. Michelle Simmons experiences are relevant to my experience.
3. I feel like I could achieve the same things as Michelle Simmons.
4. Michelle Simmons is inspiring.

5. Michelle Simmons is successful.
6. Michelle Simmons achievements seem attainable.

Video Script (manipulations are bolded)

Hardworking Script:

Science is an international language that brings people together across all nations. We are all striving to discover how the world works and how to make the world a better place. Scientists together can break down the walls that divide nations. This is the view of one of the greatest chemists on the planet, Michelle Simmons, a 50-year-old Londoner, now in Toronto Canada, heading her team of 170 top researchers, where she works in the Hospital for Children, with a goal of discovering a novel approach to treating childhood diseases like leukemia. She is inspired daily by the kids she sees and what they go through, what their families go through, and aims to provide hope to the families and to the future.

The mother of three's day begins at 9 a.m. in a cafe across the street from her lab, a taste of real life before diving into the mysteries of cancer. "It's nice being in an environment where you can get a bit of peace. You can get away from things, and you can think quite clearly. I love the kind of background noise. People are coming and going. This is the most significant part of my day. This is where I really get to think; it's where I really get to plan things."

From there she is updated on all the work of her team of scientists, 170, hand-picked brains. To be a part of this high-tech lab, you need not only exceptional skills, **but also you need to be diligent and dedicated, to ensure that persistence prevails within the group**. Everyone has the right to veto one of the newcomers. Michelle says, we spend a lot of time working together as a team, and we rely on each other. **If someone is not working hard to contribute,** we don't enjoy working with each other, and then it simply not fun anymore.”

To understand what drives Dr. Simmons, we must first revisit her childhood to understand how this young English girl got the **tenacity and the audacity** that make her one of the most skilled scientists in the world. It all began at age 8, when a memorable game of chess inspired something in the childhood of this little girl, unsure of her abilities. **She regularly observed her father take on her brother, while practicing against her friends and experiencing multiple failures**, but learning from each of her losses. Then one day she had the nerve to challenge her father. She is quoted in saying that “the look on his face was a little bit horrified and a bit dismissive, so it was rather funny. I guess that it did have quite an impact in my life the way he responded, but he played me. After about 20 minutes I checkmated him, and he was completely shocked.”

Michelle’s commitment to learning propelled her to surpass her peers. This would be confirmed at age 12, when she was one student, among many, that stood out to her physics teacher, who recognized **her ambition and commitment to understanding chemistry**, at the time, a discipline almost exclusively reserved for boys. From there, **her drive did not go unnoticed,** attending Cambridge, Berkeley, Yale, the epitome of excellence. Dr. Simmons **continued to fine-tune her skills** which allowed her to study at the finest universities. University faculty members were quick to notice **her persistence and tireless efforts to advance her knowledge of difficult concepts, earning** her several prestigious lab positions throughout her undergraduate, graduate, and post-doctoral careers. I**f she did not understand a concept immediately, she would keep at**

it and keep searching for answers until she understood.

Meanwhile, Dr. Simmons fully intends to leave the field with a medical innovation that looks at how drugs can be designed to treat specific cancer cells, targeting specific pathways that allow people to get better much faster. **She believes that with enough effort and the right attitude anything is possible**. The Canadian government saw the wisdom in this and in 2015 allocated a twenty-five-million-dollar grant through the National Innovation and Science agenda, that allows research for future development in cancer research. Prime Minister Justin Trudeau is personally following the works progress. **He believes that Michelle has what it takes to see the project through till the very end.** She is at the forefront of global research and will continue to make progress, to provide hope to the families affected by cancer and to the future.

Gifted Script:

Science is an international language that brings people together across all nations. We are all striving to discover how the world works and how to make the world a better place. Scientists together can break down the walls that divide nations. This is the view of one of the greatest chemists on the planet, Michelle Simmons, a 50-year-old Londoner, now in Toronto Canada, heading her team of 170 top researchers, where she works in the Hospital for Children, with a goal of discovering a novel approach to treating childhood diseases like leukemia. She is inspired daily by the kids she sees and what they go through, what their families go through, and aims to provide hope to the families and to the future.

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From there she is updated on all the work of her team of scientists, 170, hand-picked brains. T**o be a part of this high-tech lab, you need not only exceptional skills, but also the innate ability for understanding chemistry that only the brightest possess, ensuring that nothing interferes with the research team's progress.** Everyone has the right to veto one of the newcomers. Michelle says, **"we spend a lot of time working together as a team and we rely on each other. If someone isn't brilliant, we don't enjoy working with each other, and then it simply isn't fun anymore".**

To understand what drives Michelle, we must first revisit her childhood to understand how this young **English girl's natural talent** makes her one of the most **brilliant** scientists in the world. It all began at age 8, when a memorable game of chess triggered something in the childhood of this little girl. **She regularly observed her father take on her brother, until the day when she voiced that she wanted to challenge her father.** She is quoted in saying that "the look on his face was a little bit horrified and a bit dismissive, so it was rather funny. I guess that it did have quite an impact in my life the way he responded, but he played me. After about 20 minutes I checkmated him, and he was completely shocked."

Michelle's talent propelled her in her achievements, surpassing her peers. This would be confirmed at age 12, when she was one student, among many, that stood out to her physics teacher, **who recognized her gift for understanding chemistry,** at the time, a discipline almost exclusively reserved for boys. From there, her abilities did not go unnoticed, attending Cambridge, Berkeley, Yale, the epitome of excellence. **Michelle continued to show remarkable skills,** which allowed her to study at the finest universities. University faculty members were quick to notice **her gifts for understanding the field of chemistry; offering** her several prestigious lab positions throughout her undergraduate, graduate, and post-doctoral careers.

Meanwhile, Michelle fully intends to leave the field with a medical innovation that looks at how drugs can be designed to treat specific cancer cells, targeting specific pathways that allow people to get better much faster. **She believes that with brilliance, anything is possible.** The Canadian government saw the wisdom in this and in 2015 allocated a twenty-five-million-dollar grant through the National Innovation and Science agenda, that allows research for future development in cancer research. Prime Minister Justin Trudeau is personally following the works progress. **He believes that Michelle has the raw talent to make the project a success.** She is at the forefront of global research and will continue to make progress, to provide hope to the families and to the future.