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What makes a role model motivating for young girls? The effects of the role model's growth versus fixed mindsets about ability and interest

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ABSTRACT

Successful women role models can be—but are not always—effective in increasing pursuit of science, technology, engineering, and mathematics (STEM) careers among girls. What makes a woman role model motivating for young girls? An experimental study (N = 205 girls aged 5–8 years; 42.0% girls of color) investigated the effects of a role model's messages about her own ability and interest. The model portrayed her ability and interest as quantities that developed over time (a growth mindset) or that had always been present (a fixed mindset). The role model's growth (vs. fixed) mindset messages about ability—but not interest—increased girls' interest and self-efficacy in the scientist's field, but these effects were observed only among girls of color (ds = 0.56 and 0.65 for interest and self-efficacy, respectively). The findings contribute to theory on role models and growth mindsets, and they also have implications for the design of effective role model interventions.

Introduction

The gender gap in science, technology, engineering, and mathematics (STEM) is a long-standing societal problem. Even though the gender gap in STEM achievement has all but disappeared

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(e.g., Voyer & Voyer, 2014), women are still less likely to pursue STEM majors in college than men (e.g., National Science Foundation, 2023). This pattern suggests that equalizing achievement is not sufficient to achieve gender balance in STEM. Among other factors, increasing girls' *motivation* to pursue STEM early in their educational trajectory may be key as well (Jiang et al., 2020) because their motivation declines throughout the school years (Master et al., 2021; Wigfield et al., 2015). To help develop and maintain girls' motivation in STEM, resources for parents and educators often recommend exposing girls to successful women scientists who can serve as role models (Dean, 2014; Levere, 2018).

What do we mean by "role models"? Following a distinction commonly made in the literature (e.g., Gladstone & Cimpian, 2021), we differentiate role models from mentors and sponsors. In contrast to mentors and sponsors, it is common for role models, whether they are historical figures (e.g., Marie Curie) or currently active scientists, not to have any direct interaction or connection with students. In fact, exposure to role models often occurs exclusively through printed materials and other media. Thus, we define a STEM role model as an adult who can act as an exemplar of success in a STEM career but who does not have a personal relationship with the children to whom the adult is being introduced as an exemplar.

Although there is much enthusiasm for role model interventions among both researchers and the general public (e.g., Gladstone & Cimpian, 2021; Lawner et al., 2019; Olsson & Martiny, 2018), exposure to a same-gender role model is not always motivating for girls and can even backfire, particularly when the role model's success seems unattainable (e.g., Lockwood & Kunda, 1997). Thus, careful experimental work is needed to examine what makes a same-gender role model motivating for girls. This need is magnified when it comes to role models for *young girls* because most of the experimental work to date focuses on adolescents and young women (Gladstone & Cimpian, 2021) and—with a few recent exceptions (e.g., Shachnai et al., 2022)—the existing research on young girls' reactions to same-gender role models is not experimental. The focus on young girls may seem surprising; why not focus on adolescence, when girls are actually in a position to begin making career decisions? Crucially, research over the last decade has revealed that the psychological processes that undermine girls' pursuit of STEM, including the negative stereotypes that target their group in this domain (e.g., Bian et al., 2017; Cvencek et al., 2011, 2015; Law et al., 2021; Master et al., 2021), have their beginnings during early childhood, making this stage of development a fruitful target of intervention.

In the current research, we began to fill this gap in the literature by examining how the messages that are conveyed by a woman role model about her pursuit of STEM influence young girls' motivation—in particular, their *interest* and *self-efficacy* (e.g., Bandura, 1982) in the role model's STEM field. Our focus on interest and self-efficacy as measures of motivation is rooted in the situated expectancy–value theory of motivation (e.g., Eccles & Wigfield, 2020), according to which an individual's motivation to pursue a goal is a joint function of two quantities: the value that the individual places on that goal (here, interest) and the expectation that the individual can be successful in pursuing that goal (here, self-efficacy). Specifically, we investigated how girls' interest and self-efficacy are shaped by whether a woman role model portrays her ability and interest in STEM as fixed versus malleable.

Growth and fixed mindset messages: Why do they matter for role model interventions?

The premise behind role model interventions is simple: Exposure to a successful exemplar should motivate students. In reality, however, the motivational processes set into motion by exposure to a role model are complex. For our purposes here, a distinction can be drawn between the motivational effects of the role model's social identities and the content of what the role model says (or what is said about the role model) to students. In and of themselves, the social identities that a role model is perceived to embody (e.g., she is a woman in STEM) can be motivating or demotivating to students, depending on what these identities signal about who belongs in STEM (for a review, see Lawner et al., 2019). Our focus here, however, was on the second pathway—through the role model's messages, particularly as they concern the sources of role models' success in STEM. Most role model interventions include a biographical component that is intended to provide students with insight into the role model's path to success. Multiple motivation theories converge on the conclusion that the

perceived *attainability* of the role model's success matters for students' motivation and should be emphasized in these biographical messages (for a review, see Gladstone & Cimpian, 2021). All other things being equal, the more attainable the role model's success seems, the more likely it is that students will become energized to follow in the model's footsteps. But what exactly makes a role model's success seem attainable? Mindset theory (e.g., Dweck, 2006) provides a useful way of thinking about this question, which we elaborate on next.

The term "mindsets" refers to individuals' beliefs about the malleability (vs. fixedness) of human characteristics, with most research to date concerning beliefs about ability (for a summary, see Dweck, 2006). These beliefs fall along a continuum, with *growth* mindsets at one end and *fixed* mindsets at the other. A growth mindset about ability is the belief that ability in a domain is dynamic and can be developed over time with effort and mentoring. In contrast, a fixed mindset about ability is the belief that ability in a domain is inherent and unchangeable over time. When espoused by a role model, these two mindsets are likely to send very different messages about the attainability of success in STEM. For example, if a role model's description of her success seems to suggest a fixed mindset about STEM ability, this may signal to students an exclusionary view of success in this domain: Some people are born with what it takes to succeed and others are not, and there is nothing they can do about it. In light of the stereotypes against girls' STEM-relevant abilities (for a review, see Boston & Cimpian, 2018), this fixed message could demotivate girls by making success in STEM feel unattainable. In contrast, if a role model's description of her success suggests a growth mindset about STEM ability, that might make it seem attainable to any girl willing to work to develop her abilities. In summary, a woman role model's messages about whether her own ability in STEM was malleable versus fixed could have implications for students' motivation by making success in this domain seem more versus less attainable, respectively.

Previous research provides indirect evidence for this possibility by demonstrating that students' motivation is often shaped by mindset-relevant messages from important socializers such as teachers and parents (e.g., Cimpian et al., 2007; Gunderson et al., 2018; Pomerantz & Kempner, 2013; Porter et al., 2022). For instance, longitudinal evidence suggests that children whose mothers use more fixed-mindset praise (e.g., "You are smart") become less likely to take on challenges in school and thus are more likely to miss important learning opportunities (Pomerantz & Kempner, 2013). In the literature on role models, experimental studies by Lin-Siegler et al. (2016), whose sample included high school students, and Haber et al. (2022), whose sample included 4- and 5-year-old children, found that participants who were given examples of how famous scientists (e.g., Albert Einstein, Marie Curie) struggled in their work subsequently showed an improvement in STEM-related outcomes (e.g., learning, persistence), arguably because the role models' struggles made their success seem more attainable. It is unclear, however, whether the role models' struggles made their success seem more attainable by conveying a growth mindset or simply by suggesting that the role models' STEM abilities were not super-human, countering popular culture depictions of science heroes such as Albert Einstein and Marie Curie. More directly related to mindsets, Bagès and colleagues (Bagès & Martinot, 2011; Bagès et al., 2016) found that fifth- and sixth-grade girls performed better on a math test when they heard about an older peer whose success was said to be rooted in effort (vs. giftedness). However, it is unclear whether these results extend to younger girls, to motivation-related outcomes, and to role models as defined here—that is, adult scientists (rather than peers), who are the most common type of role model used in interventions (e.g., Lawner et al., 2019).

Although most research on mindsets has focused on ability, recent evidence has suggested that mindsets about *interest* are also influential (e.g., O'Keefe et al., 2018, 2021). Similar to fixed mindsets about ability, thinking about one's interests as fixed and stable (vs. malleable and dynamic) makes it more difficult not only to develop new interests (O'Keefe et al., 2021) but also to maintain motivation in a domain of current interest in the face of difficulty (O'Keefe et al., 2018). Anecdotally, fixed mindsets of interest are common in popular-media portrayals of scientists, who are often described as obsessively passionate about science from a young age. For instance, a best-selling children's book about the 19th-century mathematician Ada Lovelace suggests that, as a child, she filled the pages of her diary with "inventions and equations" (e.g., Wallmark, 2015). In line with fixed mindsets about

ability, fixed mindsets about interest may signal to students that if they do not already have an interest in STEM, they will not be able to develop one, which would mean that success in STEM is unattainable. These negative inferences may be particularly likely to affect girls given the negative stereotypes against their interest in STEM (Master et al., 2021). In summary, a woman role model's messages about whether her own interest in STEM was malleable versus fixed could have implications for girls' motivation by making success in this domain seem more versus less attainable, respectively. No research we know of has investigated how a woman role model's messages about her interest in her field affect young girls.

Children's race/ethnicity as a potential moderator of the effects of mindset messages

Our main goal in the current research was to investigate how a woman role model's messages about her ability and interest in STEM affect young girls' STEM motivation. However, there may be systematic differences between girls in how they react to the role model's messages; these differences are important to understand for purposes of both building theory and improving the effectiveness of role model interventions. Here, we focused on girls' race/ethnicity as a potential moderator of the effects of role models' messages on girls' motivation. Two lines of evidence motivate the prediction that girls' race/ethnicity will be a moderator. We describe each in turn.

First, negative stereotypes that are relevant to STEM pursuits (e.g., stereotypes about intellectual ability) target White girls (vs. boys) more strongly than girls (vs. boys) of color (e.g., Bian et al., 2017; Zhao et al., 2022). In addition, some evidence suggests that STEM-relevant gender stereotypes are endorsed more strongly by White girls than by girls of color (e.g., Evans et al., 2011; O'Brien et al., 2015). If, as this evidence seems to indicate, White girls are more vulnerable to negative stereotypes in STEM, perhaps they will benefit more from a role model's growth (vs. fixed) messages than girls of color; growth mindsets can be an effective buffer against negative stereotypes (Good et al., 2003).

Second, members of different racial/ethnic groups may differ in their own mindsets, which in turn may moderate the effectiveness of a role model's messages on this topic. Specifically, some evidence suggests that students of color (in particular, Black and Hispanic/Latinx students) have weaker growth mindsets relative to White students (e.g., Snipes & Tran, 2017), which is likely an instance of the more general pattern that students faced with adversity tend to espouse more fixed mindsets (e.g., Claro et al., 2016; Destin et al., 2019). If girls of color perceive STEM ability and interest to be less malleable than White girls, perhaps their motivation will receive a greater boost from a role model's growth (vs. fixed) messages. Notably, this prediction is in the opposite direction of the one described above. Thus, although the prior literature motivates a prediction of a moderation effect by girls' race/ethnicity, it does not license strong expectations about the direction of this effect.

The current research

To understand what makes a woman role model motivating for young (5- to 8-year-old) girls, we investigated the effects of the role model's fixed versus growth mindset messages about ability and interest in her scientific field. We focused on young girls because the processes that undermine girls' pursuit of STEM (e.g., stereotyping; Bian et al., 2017; Cvencek et al., 2011, 2015) begin during early childhood. In addition, we focused on mindset messaging because of the well-documented effects of growth and fixed mindsets on young children's motivation (e.g., Cimpian et al., 2007). We expected that role model messages conveying a growth (vs. fixed) mindset about ability and interest would increase girls' own interest and self-efficacy in the role model's STEM field.[1] We also explored whether girls' race/ethnicity moderates the effects of the role model's messages. Although prior work suggested that a moderation effect is likely, it did not license clear predictions about a particular direction (i.e., whether growth mindset messages will be more beneficial for White girls or girls of color).

[1] This prediction applies most directly to children who have not already had exposure to an effective STEM role model. More generally, students whose STEM motivation is already high may be less influenced by role models.

Method

Participants

Consistent with much of the research on role models, the sample was composed entirely of girls, who are the intended audience for most role model interventions. We recruited 205 girls aged 5 to 8 years (M = 7.04 years, SD = 1.19). From this sample, 60 children were tested in person in a large city in the Northeastern United States at the onset of the study, and 145 children were tested online via Zoom due to the COVID-19 pandemic. Preliminary analyses revealed no differences by testing format, so this variable was not considered further.

In terms of race, 62.4% of the girls were White, 13.7% multiracial, 12.2% Asian, and less than 3% Black, American Indian, or Alaskan Native (9.3% of parents did not report their children's race but reported their ethnicity). In terms of ethnicity, 78.0% of the sample was not Hispanic or Latino and 16.6% was Hispanic or Latino (5.4% of parents did not report their children's ethnicity).[2] Our final analytic sample included 119 White non-Hispanic girls (58.1% of the sample) and 86 girls of color (42.0%). Although the girls of color in our study are part of several distinct race/ethnicity groups, there are important parallels in the biases and challenges that girls and women of color—regardless of their specific race/ethnicity—encounter in STEM environments (e.g., Alfred et al., 2019). Thus, we examined the role model's effect on girls of color as a group. This decision was reinforced by the fact that the different racial/ethnic groups represented among girls of color in our study did not differ in their baseline levels of interest and self-efficacy in math and science (ps > .25; see below for a description of the baseline measures).

An additional 43 girls were tested but not included in the analytic sample because their parents did not provide information on their race or ethnicity (n = 33), which is a key variable in our study, or because they did not finish the study (n = 10).

A sensitivity power analysis conducted in G*Power 3.1 (Faul et al., 2007) revealed that our sample of 205 girls provided 80% power to detect effects of the mindset manipulations as small as d = 0.39 (two-tailed test, α = .05). The minimum detectable effects for the subsamples of White girls and girls of color were ds = 0.52 and 0.61, respectively (80% power, two-tailed test, α = .05).

This research received approval from New York University's institutional review board.

All data, analytic scripts, and additional analyses (e.g., correlations, factor analyses) are shared openly on the Open Science Framework (OSF): https://osf.io/wukdy/?view_only=329bb329d7f746d889071ce804ff447b. This study was not preregistered and thus should be regarded as exploratory.

Materials and procedure

The study was administered one on one by trained experimenters and unfolded as described below. Children provided all responses verbally.

Baseline assessment: Interest and self-efficacy in science, math, and reading

At the start of the study, girls were asked about their interest and self-efficacy in science, math, and reading. The questions were analogous across domains: "How much do you like science/math/reading?" for interest (1 = *don't like it at all,* 4 = *really like it*) and "How good are you at science/math/reading?" for self-efficacy (1 = *not good at all,* 4 = *really good*). These measures were included to assess whether the growth and fixed mindset conditions were equivalent at baseline (before the manipulation) with respect to interest and self-efficacy across these three domains. Indeed, independent-samples t tests that compared children in the growth and fixed mindset conditions about ability revealed no significant differences on any of the six interest and self-efficacy items above

[2] We followed current U.S. Census Bureau guidelines in drawing the distinction between race and ethnicity in this particular way, such that ethnicity pertains just to whether an individual identifies as Hispanic or Latino (e.g., Jensen et al., 2021).

(all *ps* > .11), and neither did analogous *t* tests that compared children in the growth and fixed mindset conditions about interest (all *ps* > .25).[3]

Introducing an unfamiliar STEM career

After administering the baseline measures, the experimenter introduced girls to a novel STEM field: urban ecology. This field was chosen for two reasons. First, it is relatively unfamiliar to children, which ensures that their reactions to it are driven mainly by the messages conveyed by the role model rather than by children's prior knowledge and attitudes. Second, it was one of the careers suggested by a local zoo with which we partnered for this project. We worked with the zoo's researchers to ensure that our description of the field was accurate while also being accessible to young children.

The experimenter explained to children what urban ecologists do using simple language and illustrations (e.g., they "use science to learn about living things in cities and places where there are lots of people"; see Supplementary Text 1 in the supplementary online material [SOM]). To ensure that children understood urban ecology to be a field of science, the description repeatedly emphasized this connection (e.g., "an ecologist uses science to learn about how living things [...] all live together in the same place").

Children were asked three comprehension check questions (e.g., "OK, so what are urban ecologists? Are they scientists? Or are they artists?"). Children performed well on these comprehension checks (89% correct), suggesting that they understood the description of urban ecology and the fact that it is a science. Regardless of whether children gave the correct responses, the experimenter provided the correct response to each question and continued with the study.

Introducing the role model

Next, girls were told that they would hear an interview with a "real urban ecologist" and were introduced to the role model, "Elizabeth P." (see Supplementary Text 2 in the SOM). We used the app Bitmoji (2022) to create Elizabeth P.'s appearance because it gave us more precise control than using a stock photo. The role model's name and feminine appearance were intended to convey to children she is a woman, consistent with our focus on the factors that make women role models motivating for young girls. Several considerations guided our design choices regarding the role model's perceived race/ethnicity.[4] In a recent review of the role model literature, Gladstone and Cimpian (2021) concluded that role models from majority groups (e.g., White) sometimes demotivate students from groups that are underrepresented in STEM simply by virtue of the mismatch in demographics, which would also suppress any effects of their messages. The converse is not true, however; all things being equal, role models from underrepresented groups do not typically demotivate majority-group students simply through their demographics. In light of this evidence, we created an appearance for Elizabeth P. that evokes, or is consistent with, membership in a broad range of racial/ethnic minority groups. A validation study conducted with a sample of adults suggested that the role model's appearance fit this criterion (see Supplementary Text 3 in the SOM for details). This design choice enabled us to investigate the extent to which different messages that the role model conveys are motivating without concern that her demographics would suppress these effects.

Finally, to bolster the impression that the role model is a "real urban ecologist," which might be undermined by our using a Bitmoji avatar, we played for children audio recordings of the role model ostensibly answering questions from an interviewer. These recordings served multiple functions

[3] To be conservative, we did not adjust for multiple comparisons when performing these baseline equivalence tests, even though we performed 12 comparisons (2 types of mindset manipulations [ability and interest] × 2 outcomes [interest and self-efficacy] × 3 domains [science, math, and reading]), which substantially inflated the Type I error rate.

[4] Because our focus in the current study was not on the effects of role models' demographic characteristics but rather on the messages that role models send to children about success in their field, we did not manipulate the role model's perceived race/ethnicity. We also did not attempt to match the role model's perceived race/ethnicity to children's own. Given the broad range of racial/ethnic identities represented in our sample and the diverse ways in which racial/ethnic identity can manifest in outward appearances, it would not have been feasible to accomplish such a match. Instead, we drew on the existing role model literature (e.g., Gladstone & Cimpian, 2021) to select for Elizabeth P. a single appearance (skin tone, hair texture, etc.) that would be best-suited to allow the effects of her messages to come through—should there be any such effects.

(see more below), but one of them was to reinforce the notion that the role model is an actual person, which was important for the external validity of this research.

Delivering the manipulation: The role model's growth versus fixed mindset messages about ability and interest in urban ecology

As part of the "interview" with the role model, she was first asked two filler questions (e.g., "Can you tell us more about where you work?"), to which she gave brief answers (e.g., "Yes, I work for the U. S. Urban Ecology Center"). The key manipulation messages were delivered in response to the third and fourth questions in the interview; the content of these messages was grounded in the extensive prior literature on growth and fixed mindsets (e.g., Dweck, 2006). The order of the messages about ability and interest (and of the questions that prompted them) was counterbalanced across children. All interview questions and answers had been previously audio-recorded. This aspect of the procedure standardized the delivery of the critical manipulation messages. Importantly, the recordings were played for children on headphones, which kept experimenters unaware of the condition to which each child had been assigned.

Fixed versus growth messages about ability. When asked "How did you get to be such a great urban ecologist?", Elizabeth P. gave an answer suggesting either that she had always had an ability for math and science (fixed mindset about ability) or that she had worked hard to develop her ability in math and science (growth mindset about ability). The full script of the role model's answers to this question can be found in Supplementary Figs. 1 and 2 in the SOM.

Fixed versus growth messages about interest. When asked "How did you become interested in urban ecology?", Elizabeth P. gave an answer suggesting either that she had always been interested in the relevant subject matter (e.g., "the wild animals and plants that lived near us"; fixed mindset about interest) or that she had developed an interest in urban ecology after exploring different topics (growth mindset about interest). The full script of the role model's answers to this question can be found in Supplementary Figs. 3 and 4 in the SOM.

It is noteworthy that both growth mindset conditions discussed how the character initially lacked a characteristic (ability or interest) that is needed for a successful career as an urban ecologist and then, through her efforts, acquired that characteristic. Thus, both growth mindset conditions incorporated an element of "struggle" (in the sense of dealing with an obstacle to success), which has been identified as a component of effective role model interventions (e.g., Lin-Siegler et al., 2016). Consistent with the core of a growth mindset, the scripts in both conditions then articulated how the role model *overcame* this initial struggle.

Design

Girls were randomly assigned to one of the four conditions in the 2×2 design that resulted from crossing the two variables just described (growth vs. fixed mindsets about ability and interest). Random assignment to condition was stratified by age group (5-, 6-, 7-, or 8-year-olds). Aside from the nature of the manipulation messages, the four conditions were identical. Notably, we did not include a "pure" control condition in this study because it is hard to imagine a real-world role model intervention that says absolutely nothing about the role model's path to success. Thus, one way to think about the question asked by the current work is as follows: Premised on the need to say something about how the role model became successful, what should we say to ensure that young girls are motivated by her example?

Dependent measure: Interest in urban ecology

To assess how interested girls were in pursuing urban ecology, the experimenter asked them three questions adapted from Eccles and Wigfield (1995): (a) "How much do you want to be an urban ecologist when you grow up?" (1 = *not want to at all,* 4 = *really want to*); (b) "How much would you like it if your teacher taught you about urban ecology?" (1 = *really not like it,* 4 = *really like it*); and (c) "How fun

would urban ecology be as a job for you?" (1 = *really not fun,* 4 = *really fun*). The three items were averaged into an interest composite (α = .71). These items were presented together with the three self-efficacy items (see below) in random order.

Dependent measure: Self-efficacy in urban ecology

To assess how self-efficacious girls were with respect to urban ecology, the experimenter asked them three questions adapted from Eccles and Wigfield (1995): (a) "Imagine you became an urban ecologist when you grew up. How well do you think you would do as an urban ecologist?" (1 = *really not well,* 4 = *really well*); (b) "Imagine you became an urban ecologist when you grew up. Would urban ecology be an easy job for you to do?" (1 = *really hard,* 4 = *really easy*); and (c) "Imagine you became an urban ecologist when you grew up. How good of an urban ecologist would you be?" (1 = *not good at all,* 4 = *really good*). The three items were averaged into a self-efficacy composite (α = .70). The interest and self-efficacy measures were positively correlated, $r(203) = .61$, $p < .001$. A confirmatory factor analysis suggested that these two measures were psychometrically distinct (see "Additional Results" folder on OSF).

Exploratory items

At the end of the sessions, we asked children a few exploratory items intended to assess their perceptions of the role model and the field (i.e., urban ecology). These items do not pertain to children's motivation per se, so we do not discuss them further here. However, we list them in Supplementary Text 4 of the SOM and include some analyses in the "Additional Results" folder on OSF.

Debriefing

The sessions concluded with a debriefing in which the experimenter emphasized growth mindset messages about success in science.

Analytic strategy

To assess the effects of the role model's messages on girls' interest and self-efficacy, we conducted two linear regression models, one per outcome variable. Each regression included the role model's mindsets about ability and, separately, interest (0 = fixed, 1 = growth), children's race/ethnicity (0 = White girl, 1 = girl of color), and all interactions. Children's age (continuous; in years with 2+ decimal precision) was entered as a covariate. All predictors were mean-centered to facilitate the interpretation of the lower-order coefficients. Models were fit using Stata 16.1 (StataCorp, 2019). Because the interest outcome exhibited substantial negative skew (skewness = −0.49), departing significantly from normality (Shapiro–Wilk $W = 0.98$, $p = .009$), we computed standard errors and 95% confidence intervals (CIs) for regression coefficients via bootstrapping (10,000 replications) for both outcomes. CIs were bias-corrected and accelerated, which adjusts for the bias and skewness in the distribution of bootstrap estimates (e.g., Efron, 1987), and are reported in square brackets next to the relevant coefficients. All means reported in the text are marginal means calculated with the *margins* command in Stata, which was also used to calculate marginal tests (e.g., to follow up on significant interactions). Effect sizes for the mindset manipulations were calculated by re-running the regressions above with standardized versions of the dependent variables and consulting the relevant coefficients and marginal tests. This method produces effect size estimates analogous to Cohen's *d*s.

Results

Effects of the role model's mindset messages on girls' interest

The regression model with girls' interest in urban ecology as a dependent variable revealed a significant two-way interaction between children's race/ethnicity and the role model's fixed versus

Table 1
Regression models predicting girls' interest and self-efficacy in urban ecology

	Interest				Self-efficacy			
Predictor	*b*	*SE*	95% CI		*b*	*SE*	95% CI	
Girl of Color	0.24*	0.11	0.01	0.45	0.18~	0.10	−0.03	0.38
GM:Ability	0.16	0.11	−0.05	0.37	0.12	0.10	−0.08	0.31
Girl of Color × GM:Ability	0.48*	0.22	0.04	0.91	0.61**	0.21	0.21	1.02
GM:Interest	−0.02	0.11	−0.23	0.19	−0.04	0.10	−0.24	0.16
Girl of Color × GM:Interest	0.11	0.22	−0.33	0.53	0.22	0.20	−0.19	0.62
GM:Ability × GM:Interest	−0.12	0.22	−0.54	0.30	−0.11	0.20	−0.51	0.29
Girl of Color × GM:Ability × GM:Interest	0.11	0.44	−0.73	0.97	−0.01	0.41	−0.80	0.83
Age	−0.06	0.05	−0.15	0.04	<0.01	0.05	−0.09	0.09
Intercept	2.85	0.05	2.74	2.95	2.75	0.05	2.65	2.85

Note. CI, confidence interval; GM:Ability, growth (=1) vs. fixed (=0) mindset about ability; GM:Interest, growth (=1) vs. fixed (=0) mindset about interest. All predictors were mean-centered. Standard errors and 95% CIs were calculated via bootstrapping (10,000 replications). The CIs were bias-corrected and accelerated.
~ $p < .10$.
* $p < .05$.
** $p < .01$.

growth mindsets about ability, $b = 0.48$ [0.04, 0.91], $SE = 0.22$, $p = .031$ (for full output, see Table 1).[5] This interaction was driven by the fact that the role model's growth (vs. fixed) mindset about ability increased interest among girls of color (*M*s = 3.21 and 2.78, respectively), $b = 0.44$ [0.10, 0.78], $SE = 0.17$, $p = .011$, $d = 0.56$,[6] but had no effect on White girls' interest (*M*s = 2.73 and 2.77, respectively), $b = -0.04$ [−0.32, 0.23], $SE = 0.14$, $p = .76$, $d = -0.06$ (see Fig. 1, left). No coefficients involving the role model's messages about her interest in urban ecology were significant in this model (see Table 1). Supplementary Fig. 5 in the SOM displays the relevant means.

Effects of the role model's mindset messages on girls' self-efficacy

Similar to the analysis on interest, the regression model with girls' self-efficacy as a dependent variable revealed an interaction between girls' race/ethnicity and the role model's fixed versus growth mindset messages about ability, $b = 0.61$ [0.21, 1.02], $SE = 0.21$, $p = .003$ (see Table 1).[7] As shown in Fig. 1 (right), only girls of color showed higher self-efficacy in response to the role model's growth (vs. fixed) mindset messages about ability in urban ecology (*M*s = 3.10 and 2.63, respectively), $b = 0.48$ [0.18, 0.79], $SE = 0.16$, $p = .003$, $d = 0.65$.[8] White girls' self-efficacy was not affected by the role model's growth (vs. fixed) mindset messages about ability (*M*s = 2.60 and 2.74, respectively), $b = -0.14$ [−0.40, 0.12], $SE = 0.13$, $p = .30$, $d = -0.19$. Again, no coefficients involving the role model's messages about her interest in urban ecology were significant. Supplementary Fig. 5 in the SOM displays the relevant means.

[5] We explored whether this interaction effect differed in magnitude for younger girls (5- and 6-year-olds) versus older girls (7- and 8-year-olds). The three-way interaction between children's race/ethnicity, the role model's fixed versus growth mindsets about ability, and children's age (5- and 6-year-olds vs. 7- and 8-year-olds) was not significant, $b = 0.61$ [−0.23, 1.51], $SE = 0.45$, $p = .17$ (see "Additional Results" folder on OSF for the full results). We note, however, that our sample was likely underpowered to detect such moderation effects.

[6] Because Asian Americans are not underrepresented in STEM (National Science Foundation, 2023), we examined whether the Asian American girls in our sample ($n = 23$) showed a different pattern of results relative to the other girls of color. Even though the sample of Asian American girls was too small to conduct inferential tests, the magnitude of effect of the role model's growth (vs. fixed) mindset messages about ability on Asian American girls' interest was very similar in magnitude ($d = 0.57$) to the overall effect on girls of color ($d = 0.56$).

[7] As was the case for interest, this two-way interaction was not moderated by children's age (5- and 6-year-olds vs. 7- and 8-year-olds), $b = -0.12$ [−0.90, 0.71], $SE = 0.41$, $p = .77$ (see "Additional Results" folder on OSF for the full results).

[8] As was the case for interest, the magnitude of effect of the role model's growth (vs. fixed) mindset messages about ability on Asian American girls' self-efficacy was very similar in magnitude ($d = 0.68$) to the overall effect on girls of color ($d = 0.65$).

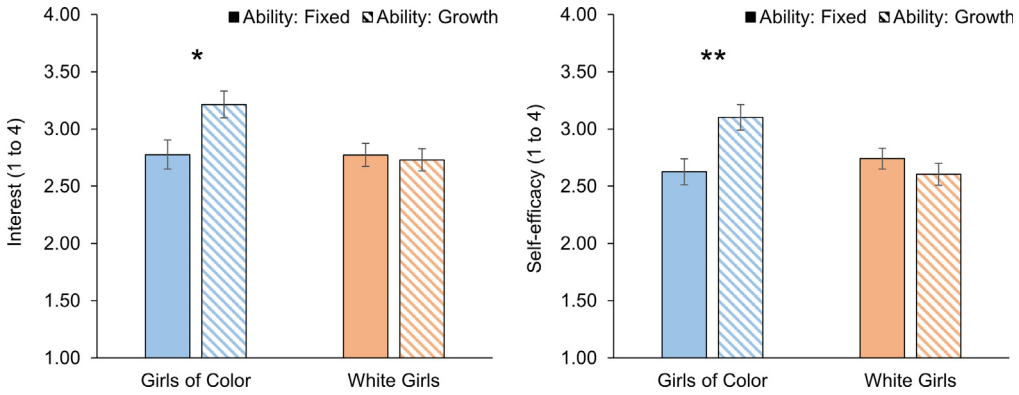

Fig. 1. Girls' interest (left) and self-efficacy (right) as a function of their race/ethnicity and the role model's growth versus fixed messages about ability. The means depicted are marginal (or adjusted) means computed from the regression models in Table 1. Error bars indicate ±1 standard error. $^{*}p < .05$; $^{**}p < .01$.

Robustness checks

To assess whether our results are robust to alternate modeling strategies, we also analyzed the data with ordered logistic regressions, which tolerate non-normality (here, skew) in the outcome. The predictors were the same as in the linear regression models reported above. Critically, the significant interactions between girls' race/ethnicity and the fixed versus growth mindset messages about ability were observed in these alternate analyses as well for both interest, $b = 1.19$ [0.19, 2.19], $SE = 0.51$, $p = .020$, and self-efficacy, $b = 1.49$ [0.50, 2.49], $SE = 0.51$, $p = .003$. We followed up on these two-way interactions with nonparametric, rank-based Mann–Whitney U tests that compared the effects of growth (vs. fixed) messages about ability on girls of color and, separately, on White girls. Consistent with the results above, girls of color showed stronger interest ($p = .008$) and self-efficacy ($p = .003$) in response to the growth (vs. fixed) mindset messages about ability, but White girls did not ($ps > .39$).

Discussion

Although exposing girls to women role models is a popular strategy to encourage girls' pursuit of STEM careers, the effects of such exposure are not entirely straightforward; whether role models increase girls' STEM motivation depends on a complex interaction among several factors (Gladstone & Cimpian, 2021; Lawner et al., 2019; Olsson & Martiny, 2018). Here, we examined one such factor: the autobiographical messages that the role model conveys about her path to success, which are a common element of role model interventions. We expected that a role model who signals a growth mindset about her abilities and interest in her chosen field would be more motivating than a role model who (while otherwise identical) signals a fixed mindset. We found support for this prediction among girls of color, who showed higher interest and self-efficacy in the role model's field of science when the role model portrayed her ability in this field as malleable (vs. fixed). These effects were medium in magnitude by conventional standards ($ds \geq 0.56$; Cohen, 1988) and were robust across modeling strategies.

Contributions to theory and practice

This result contributes to theory on both role models and growth mindsets. With respect to theory on role models, the current study is the first to document that a woman role model's expressed growth (vs. fixed) mindset about ability can increase (some) young girls' interest and self-efficacy in a previously unfamiliar science field. In experimental work on role models, much of the focus to date has been on the effect of role models' relatability to students in terms of demographic similarity (for

reviews, see Gladstone & Cimpian, 2021; Lawner et al., 2019; Olsson & Martiny, 2018). Much less work—and even less work with young children—has manipulated the perspective that the role model communicates to students about her path to success in science. The current results demonstrate that differences in the role model's perspective, specifically in whether she describes her ability as stable or as malleable over time, can be powerful: Just a few sentences in an "interview" with a role model gave rise to differences of more than half a standard deviation in the interest and self-efficacy of girls of color in the current study.

With respect to theory on growth mindsets, it is noteworthy that the mindset-relevant messages delivered in our study were neither directly about the participating children nor about any group to which they belonged, unlike most prior work (e.g., Cimpian, 2010; Cimpian et al., 2007; Gunderson et al., 2018). Rather, these messages simply conveyed an unfamiliar adult's perspective on her own success. Thus, our results highlight the power that mindset-relevant messages in young children's broader social environments have to shape their motivation (for a useful discussion of motivational climates, see Robinson, 2023).

The current work also deepens the connections between two major theories of motivation: mindset theory and situated expectancy–value theory. Although theorists have previously argued that a growth mindset about ability can boost students' expectancies for success (e.g., Wigfield et al., 2021), we are not aware of any prior arguments that link mindsets with the *value* component of situated expectancy–value theory. Here, we proposed that the role model's mindsets—and perhaps her mindset about interest in particular—may affect the value that children assign to the role model's chosen field. We did not find the predicted effects with respect to the role model's mindset about interest (see the next section for speculative reasons why), but we remain optimistic that such a link is plausible and we encourage others to explore it.

Finally, our results contribute to practical knowledge about the design of effective role model interventions. As a preamble, we should note that the format in which the girls in our study were exposed to the role model (via media and text) mirrors how many children are exposed to role models outside the lab. This approach is so popular that it has even been endorsed by some government agencies (e.g., the French Ministry of National Education and Youth, n.d.). These considerations speak to the external validity of our research: We investigated the effects of role models' messages in a context that resembles how many children, in the United States and beyond, are introduced to role models. Against this backdrop, our research suggests that role models who adopt a growth (vs. fixed) mindset when they describe their ability in their chosen field are more motivating to some young children. In addition, growth mindset messages exhibit a low risk of backfire effects; no subgroup of participants in our study was less motivated by these messages relative to fixed mindset messages. Thus, a practical takeaway from our research is that role model interventions for young girls would be well served by conveying a growth mindset perspective on role models' scientific ability.

Limitations, open questions, and future directions

Several limitations of our study are worth noting. First, we treated girls of color as a monolithic group. It is likely that finer-grained distinctions can be made between specific racial/ethnic minority groups in terms of the extent to which they are subject to stereotypes in STEM, endorse growth or fixed mindsets about ability, and so on. We encourage researchers to conduct studies with samples that are sufficiently large to allow such distinctions, if present, to be identified. Second, we included only girls as participants. Although this is common in the literature on role models, our decision to focus exclusively on girls prevented us from examining how broadly the effects of a woman role model's growth (vs. fixed) mindset messages generalize: Are some boys motivated by them as well? Third, our decision to fix the role model's perceived race/ethnicity rather than varying it orthogonally with her mindset messages meant that we were unable to investigate whether her racial/ethnic identity moderates the effect of her messages. Fourth, we measured the motivational effects of the role model only immediately after exposure to her messages. Examining how long-lasting these effects are would be worthwhile.

An important question left open by the current work is why messages conveying growth mindsets about ability were effective only among girls of color. One possibility is that children of color are more

likely to adopt a fixed mindset about ability (Snipes & Tran, 2017), and growth mindset interventions find significantly stronger effects on students who, at baseline, have more of a fixed mindset (e.g., Yeager et al., 2022). Extrapolating to our study, perhaps girls of color were more strongly influenced by the role model's growth mindset messages because their preexisting mindsets were more fixed. If so, then future studies that measure children's baseline mindsets should find that children with more of a fixed mindset at baseline are more likely to benefit from a role model's growth-oriented perspective.

Another reason why the role model was particularly inspiring for girls of color may be that children, like adults (see Supplementary Text 3 in the SOM), probably perceived her as a person of color. The broad match in social identities between the role model and girls of color may have amplified the positive effects of the role model's growth (vs. fixed) mindset messages on their motivation. Consistent with this explanation, we also observed main effects of girls' race/ethnicity on their interest and self-efficacy after exposure to the role model (see Table 1): Girls of color were more motivated by the role model overall regardless of what she said.[9] Notably, girls of color and White girls did not differ in their interest and self-efficacy in science, math, or reading at baseline (all *ps* > .22).

Another open question concerns the null effects of the role model's messages about her interest. It is puzzling that these messages did not have an effect on children considering especially that one of our outcome variables was precisely their interest. Previous research has found that messages about growth (vs. fixed) interest led to an openness (interest) to learn more about an unfamiliar field (O'Keefe et al., 2018), and therefore one might have expected this finding to replicate in the current study. This surprising result highlights the need for a better understanding of the development of children's mindsets about interest. The few studies that have investigated this new construct focus exclusively on adults (e.g., O'Keefe et al., 2018, 2021), so it is currently unclear whether young children's reasoning about interests can accommodate both fixed and growth mindsets about this psychological characteristic. Other research suggests that reasoning about preferences and interests undergoes considerable changes over the course of early childhood, with children in the age range included here showing relatively little awareness that a person's interests can change as a function of what they are exposed to in their environments (e.g., Taylor et al., 2009). Another potential reason why the role model's messages about her interest were less effective than the messages about her ability is perhaps that the magnitude of the change described with respect to her interests was less striking: The transition from getting bad grades in math and science to excelling in these subjects is notable; perhaps the shift from lacking interest in a topic to becoming interested in it is less dramatic an illustration of a growth mindset. The comparatively subtle nature of this shift may have diminished the impact of the role model's growth mindset messages about her interests. Exploring this possibility is a fruitful topic for future research.

Although here we chose to examine the effects of a woman role model's messages about ability and interest among young children, it will be important for future work to examine the impact of these messages among adolescents. Our focus on young children was motivated by the evidence that stereotypes relevant to STEM pursuit are acquired from a young age (e.g., Bian et al., 2017; Zhao et al., 2022); therefore, tackling these stereotypes early may be fruitful for the development of STEM motivation (e.g., Eccles & Wigfield, 2020). However, STEM course and career choices do not become as apparent until adolescence, when students start to have more control over their educational trajectories. Thus, the use of role models portraying growth mindset messages about ability and interest may also be beneficial for older students. These ideas require further empirical exploration.

Conclusion

The current study suggests that women role models who communicate a growth (vs. fixed) mindset about their ability in their chosen field of science are motivating for girls of color. This finding contributes to theory on role models and growth mindsets during childhood, and it has direct implications

[9] Similarly, the exploratory items administered at the end of the sessions suggested that girls of color liked the role model more and wanted to be like her more when they grew up compared with White girls (see the "Additional Results" folder on OSF).

for the design of effective role model interventions aimed at helping students from marginalized backgrounds to pursue STEM careers.

Data availability

All data and analytic scripts are shared openly on the Open Science Framework (OSF): https://osf.io/wukdy/?view_only=329bb329d7f746d889071ce804ff447b.

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Appendix A. Supplementary material

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