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Children's math and science beliefs about underrepresented peers are related to STEM occupation expectations

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ABSTRACT

Children's interest and motivation in math and science decline dramatically beginning as early as elementary school (K-5). This is especially true for marginalized students, such as girls and children from underrepresented racial-ethnic minority (URM) backgrounds. Understanding the relation between children's STEM (science, technology, engineering, and math) competence beliefs and STEM occupation expectations provides a basis for timely and targeted intervention. This association is crucial because expectations about who will pursue and engage in STEM occupations reveals potential biases that might translate into exclusion of participation from STEM-related activities in childhood. To examine this topic, a survey was administered to $N = 842$ children ages 7–12 years from different racial-ethnic backgrounds in the suburbs of a large Mid-Atlantic city. As hypothesized, we found that math and science competence beliefs about girls predicted children's expectation that a girl, rather than a boy, would grow up to be a scientist and a doctor. Further, math and science competency beliefs about URM peers predicted children's expectation that a Black or Latine child would grow up to be a doctor, though these beliefs were not related to their expectations that a Black or Latine child would grow up to be a scientist. Additionally, participants were more likely to expect a girl to grow up to be a doctor than to be a scientist. The effects of participant age, gender, and race were also investigated. These findings contribute to understanding how best to broaden participation in math and science fields for all children.

Introduction

Science, technology, engineering, and mathematics (STEM) form the basis for the U.S.'s innovation, competitiveness, companies, and industries (Athanasia & Cota, 2022). Yet, extensive developmental, cognitive, and psychological research has demonstrated that student interest and motivation in STEM subjects declines beginning as early as elementary school (K-5) (Aschbacher et al., 2013; Cvencek et al., 2021; Lei et al., 2019; Wang & Eccles, 2013). This is particularly true for girls and underrepresented racial-ethnic minority (URM) students (Brantlinger, 2018; Master, 2021; Wang & Degol, 2017). Research has shown that a lack of interest or feeling of identification with a subject matter in school is related to low motivation in that subject (Eccles & Wigfield, 2020).

Given that science and math are core foundational subjects in elementary and primary school, it is important to understand the

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factors that limit participation in these two STEM areas. Science and math literacy is necessary for success in school which contributes to preparation for a workforce that increasingly relies on technological skills and competence. Most research on factors that contribute to a decline in gender and URM students' interest in STEM has focused on college (Dunlap & Barth, 2023) with some attention paid to high school or secondary school experiences (Starr & Simpkins, 2021). Much less focus has been targeted on elementary school (K-5) students despite evidence that biases about STEM abilities and competence begin in childhood (Bian et al., 2017; McGuire et al., 2020b; Mulvey & Irvin, 2018). Given that STEM interest and motivation declines by middle childhood for marginalized groups such as girls and URM students (McGuire et al., 2020b), focused attention on how children make connections between STEM competence and occupations provides a basis for early intervention. Early intervention is important given that attitudes are increasingly more difficult to change as individuals get older. Thus, understanding how children's biases about STEM abilities and competence are related to expectations about future occupations is essential for preparing educators to address these issues in early and middle childhood.

Why is it important to reduce STEM-related biases?

One of the many negative outcomes of experiencing STEM-related biases is that it limits children's access to and success in STEM-related activities, thus reducing their chances for success in STEM fields. This is important because being excluded from STEM-related activities represents a missed opportunity to be associated with high-status activities and occupations. As early as high school, STEM jobs are associated with high pay, prestige, and intelligence (Rosenzweig & Chen, 2023). Excluding segments of the population, such as girls and underrepresented minority (URM) individuals from high-status jobs contributes to unfair social status hierarchies. A potential outcome of this form of exclusion is that only selected segments of society, those who are not recipients of negative stereotypic expectations, have an opportunity to enter STEM fields. Not only does this reduce the potential size of the STEM-ready workforce but it also contributes to inequalities based on wealth given that STEM-related jobs often reflect high pay and forms of compensation (Redhead & Power, 2022). Status hierarchies emerge in children's worlds based on potential occupations and professions. Moreover, even young children form conceptions about status and inequalities based on group identity (Heck et al. 2022). Individuals may hold or be the target of group-based exclusionary STEM beliefs starting early in childhood.

Further, viewing oneself as not belonging in science and math impacts children's educational trajectory (Master et al., 2021). Avoiding STEM-related classes in K-12 education makes it more difficult to enroll in STEM fields in college given the lack of adequate preparation. Without access to STEM-related preparation in higher education, individuals are at a disadvantage when entering the competitive workforce in jobs and careers that require science, technology, engineering, and math competence. This, in turn, can have negative consequences for their lifetime earnings and a host of other lifespan outcomes regarding mental and physical health (Chetty et al., 2016; Okrent & Burke, 2021).

To reverse this trajectory, it is necessary to investigate children's expectations about math and science capacities as well as children's beliefs about who is likely to have STEM-related occupations in adulthood (Master & Meltzoff, 2020). Further, stereotypic beliefs and attitudes have been found to be more malleable in childhood, as stereotypes are not as deeply entrenched as in adulthood (Rutland & Killen, 2015). Thus, understanding the connections between children's expectations about others' math and science competence and their future occupation potential in STEM is warranted.

Theoretical model

Drawing on social identity theory and social domain theory, the social reasoning developmental (SRD) model predicts that children and adolescents hold stereotypic expectations about groups based on developing conceptions of group identity and group norms but also recognize that inclusive perspectives are important. One aspect of inclusive perspectives includes judgments about the equality of opportunities. Rather than being a contradictory orientation, SRD postulates that individuals care about group identity and affiliation but also value equality and fairness. A goal of the SRD model is to identify the situations that promote inclusive perspectives as well as those that appear to motivate in-group bias or outgroup dislike (Killen & Rutland, 2011; Elenbaas et al. 2020).

Recently, a line of research guided by the SRD model has demonstrated this coexistence of group biases (preferences based on gender, race, or ethnicity) and inclusive viewpoints (fairness and equality) regarding expectations about who can participate in STEM-related activities in childhood (Mulvey & Irvin, 2018; Mulvey et al., 2023; McGuire et al., 2022). This research, which examines children's judgments and interpretations of STEM-focused situations, has revealed that children display both ingroup biases and value equality, particularly when making decisions about others' competence in math and science. These judgments and attitudes often bear directly on decisions to include or exclude others in group contexts where individuals consider factors such as group cohesion, group functioning and group norms. In one study (McGuire et al., 2020a), boys ages 9 – 11 years expected that their peers would negatively evaluate a boy who wanted to participate in a girl-focused STEM activity (e.g., biology), but girls did not negatively evaluate a girl who wanted to participate in a boy-focused STEM activity (e.g., programming). This suggests that boy peer groups may reinforce gender stereotypic participation in STEM activities.

Another study (Mulvey & Irvin, 2018) found that children ages 3–8 years positively evaluated characters who wanted to support counter-stereotypic STEM careers based on gender and race, but younger children judged counter-stereotypic career choices as less acceptable than did older children (Mulvey & Irvin, 2018). With age children became more inclusive in their STEM occupation expectations (e.g., children's expectations regarding *who* can participate in different STEM occupations). The present study drew on the SRD model to investigate whether children who held fewer stereotypic expectations about peers' STEM abilities would be more likely to have counter-stereotypic predictions about future STEM occupations based on gender and race. We investigated whether the gender, race, and age of the participants played a role in how they responded.

Differing expectations within STEM occupations

Not all STEM-related occupations have the same status associations nor the same level of representation from different social groups. For example, while women are well represented in biological fields, such as medicine, their representation in fields such as engineering, technology, and physical sciences is much lower (between approximately 4 % and 20 %) (Charlesworth & Banaji, 2019; Cheryan et al., 2017; National Science Foundation, 2024). A recent review of adolescents' preferences for STEM occupations revealed that adolescents' preferences for STEM occupations differed by the particular profession, participant gender, and participant race (Rosenzweig & Chen, 2023). For example, Rosenzweig and Chen (2023) found that girls were more likely to prefer healthcare STEM professions, and least likely to prefer computer science-related careers (see also McGuire et al., 2020a). In contrast, boys were more likely to prefer engineering, computer science, and machine-operated STEM careers than health-related professions, with an exception that Black boys also preferred doctorate-level health care, as did girls. Thus, data from Rosenzweig and Chen (2023), reveal more pronounced gender differences than differences by racial and ethnic backgrounds. To understand more about the developmental trajectory of these preferences expressed by adolescents, we incorporated the distinction between two STEM-related professions, scientist and doctor, in the design of the current study focused on middle childhood.

Regarding expectations about a scientist, research using the "Draw-A-Scientist" task has shown that most children draw an older White man when given the opportunity to draw a scientist, reflecting an expectation that science is associated with individuals from a select gender and racial background (Fort & Varney, 1989; Miller et al., 2018). A meta-analysis reporting on the Draw-A-Scientist task found that girls on average drew 58 % of scientists as male, whereas boys drew 96 % as male (Miller et al., 2018). Younger girls on average drew 30 % of scientists as male at age 6 (early elementary school) but switched to drawing more males by ages 10–11 years. By age 16 (high school), girls on average drew 75 % of scientists as male.

These age-related changes regarding who looks like a scientist may contribute to gender differences in adolescents' preferences for being a scientist. In contrast, for boys, the mean percentage of male scientists changed from 83 % to 98 % between ages 6 and 16 years. This suggests that for children ages 7 – 12 years, the sample age range for the current study, boys would be more likely than girls to draw a man rather than a woman as a scientist; however, specific age delineation was not provided in the meta-analysis. Yet, based on these general findings (Miller et al., 2018), we might expect that boys would expect that boys, rather than girls, will grow up to be scientists.

While research has examined what children think a scientist looks like, much less research has examined children's differential expectations regarding different professions within STEM fields. Women have been stereotyped by adults as being more equipped than men for "caring professions," such as nursing (Mundim et al., 2024) and are most likely to select the biological sciences, among STEM fields, as a college major (Mann & DiPrete, 2013; Sassler et al., 2017). Furthermore, in HEED (healthcare, early education, domestic) occupations women continue to be overrepresented and men are underrepresented (European Commission, 2021). Research on adolescents' stereotypic attitudes about HEED occupations has shown that parental gender-stereotypic attitudes about HEED professions predicted adolescents attitudes (van de Rozenberg et al., 2024). As being a doctor may be seen as both a STEM *and* a HEED occupation, it may be that children expect for a girl to be a doctor more than they expect a girl will be a scientist, though research has not yet examined this question.

Both children's gender and racial-ethnic expectations of who will pursue STEM careers may be related to their stereotypes about the status of these professions. Research with elementary school-aged Black children regarding their perceptions of occupational status revealed that their ratings of occupations associated with high concentrations of White adults were rated higher than those occupations associated with high concentrations of Black adults (Bigler et al., 2002). The list of high-status occupations shown to children was varied and included pilot, dentist, doctor, and scientist, indicating that most of these positions were also STEM-related. In contrast, occupations rated as medium- or low-status were not STEM related (e.g., police officer, bank teller, mail carrier). Importantly, participants viewed "both Whites and Blacks" as capable of performing the occupations. Thus, in this study, children were aware of the connection between status and race but did not view this connection as a reflection of occupational competence. This present study built on these findings by examining whether children have expectations for girls and URM peers to grow up to be a doctor or a scientist. Expectations about future occupations are distinct from math and science competence beliefs, which refer to who children think is good (or not good) at STEM-related abilities and may also differ depending on the gender or race of the target group. Negative expectations about who can become a scientist may contribute to a lack of belonging and identification with the field of science for many children (Cheryan et al., 2009; Cheryan & Plaut, 2010; Master, 2021).

It is important to understand how children's beliefs about the math and science abilities of marginalized groups (girls and URM individuals) may influence their expectations for members of these groups to enter high-status occupations. This knowledge will contribute to the goal of enabling fair and equal access for all individuals to pursue STEM careers and fields.

Gender, underrepresented minority status, and STEM competence

Research on stereotypic expectations about STEM in childhood has shown that characteristics related to success in STEM areas, such as intelligence and effort ("hard-working"), are associated with White and Asian individuals and boys (Bian et al., 2017; Brown, 2017; McGee et al., 2017; Rizzo et al., 2022). Conversely, girls and URM children, such as Black and Latine students, are rarely associated with intelligence and effort when it comes to STEM-related fields (Bian et al., 2017). While research has more extensively examined how girls think about STEM-related competence than about how URM children think about them, findings on STEM learning environments have demonstrated that girls and URM students experience exclusion from STEM learning opportunities in both explicit and implicit ways (Charlesworth & Banaji, 2019; Joy et al., 2023; Robnett & John, 2020).

Specifically, Bian et al. (2018) has shown that children view men as more likely to be "brilliant" than women. Whereas 5-year-olds reveal an ingroup preference about who is "smart" (e.g., thinking that a member of their gender ingroup will be smarter than a member of their gender outgroup), by 7 years of age both boys and girls demonstrate an expectation that boys are smarter than girls, as evidenced by their preference to choose a boy rather than a girl to be on a team that requires intelligence. Bian et al. (2018) interpret these findings to suggest that bias against girls and women where "brilliance" is highlighted emerges early and becomes an obstacle for success.

Related research has documented that children appear to associate White men (vs. women), but not Black men (vs. women), with brilliance (Jaxon et al., 2019). One of the outcomes of this bias is that children appear to view Black men as less "brilliant" than Black women and that this assumption about brilliance occurs for children from a variety of different racial-ethnic backgrounds (Jaxon et al., 2019). These biases have negative implications for the goal of all children experiencing equal access and belonging in STEM-related activities and opportunities (Cheryan et al., 2009). Further, cross-sectional and longitudinal data from the High School Longitudinal Study of 2009 has revealed that girls, Black, Hispanic, and low SES students are less likely to display an interest in STEM activities during adolescence (Saw et al., 2018). The exclusion that girls and URM students often experience from STEM learning opportunities in childhood may contribute to their reduced interest in STEM activities by adolescence.

Reducing negative stereotypic expectations about competence for a given group, however, is not enough to broaden participation in STEM. Even "positive" stereotypes can have negative consequences, such as when Asian students are labeled as being good at math and science, "just because they are Asian" (McGee et al., 2017; Trytten, et al., 2012). It is also necessary to reduce exclusionary norms about who "fits" in STEM-related fields and increase identity with STEM for groups that have been the recipients of both negative and positive stereotypic expectations (Cheryan et al., 2015). Increasing expectations that anyone can be good at math and science, as examples, will help to foster a sense of belonging in STEM for all individuals (Cheryan et al., 2015; Master et al., 2015). This is due, in part, to findings that show that a lack of interest and motivation to take STEM-related classes in school may be related to messages that your group identity (e.g., gender, race, ethnicity) does not belong (Master et al., 2016).

The present study

Motivated by the prior research and the SRD model, we investigated the connections between beliefs about STEM competence for girls and URM peers and children's expectations that these individuals would have a high-status STEM occupation as an adult. A survey was administered to children measuring their beliefs about the math and science competence of girls as well as Black and Latine peers (e.g., how good or bad they think members of these groups are at math and science). We chose to focus on two specific STEM skills: math and science. Importantly, math and science are viewed as core capacities that are required for a range of STEM occupations. We measured children's predictions about which peers they expected to grow up to be a doctor and a scientist. We selected these two high-status occupations because they reflect the use of STEM competence (e.g., biology and math) which would be familiar to children ages 7 – 12 enrolled in elementary school in the U.S. We also choose the occupations of doctor and scientist as they reflect adolescents' preferences of future STEM occupations (Rosenzweig & Chen, 2023). This raises the question of whether these distinctions emerge prior to adolescence.

Hypotheses

Gender and Age. We predicted that children who have higher math and science competence beliefs about girls would be more likely to expect that a girl will grow up to be a scientist and doctor (H1). Based on prior literature showing that boys have more stereotypic expectations about STEM occupations than girls (Miller et al., 2018), we expected an interaction between participant gender and competence beliefs about girls, such that, for boys more so than girls, math and science competence beliefs would be more strongly predictive of selecting that a girl will grow up to be a scientist or doctor (H1a). As previous literature has shown that with age children show less bias generally (Elenbaas et al., 2020) and specifically regarding STEM biases (McGuire et al., 2022), we also expected that with age, children would have a higher likelihood of predicting a girl to be a doctor and a scientist (H1b). Additionally, based on expectations that the "caring professions" are associated with women more than men (Mundim et al., 2024) and that doctors are also a part of the HEED fields, where women are overrepresented and men are underrepresented (European Commission, 2021), we predicted that children would be more likely to expect that a girl would be a doctor than that a girl would be a scientist (H2), and that this difference would be stronger for boys (H2a).

Race-ethnicity and Age. We predicted that children who have higher math and science competence beliefs about underrepresented minority (Black and Latine) peers would be more likely to predict that a Black or Latine peer will grow up to be a doctor or a scientist (H3). More specifically, we predicted that for children who are not underrepresented minorities in STEM (White and Asian participants), more so than for Black or Latine participants, math and science competence beliefs about URM peers would be more strongly predictive of selecting a URM child to grow up to be a scientist or doctor (H3a). We also predicted that with age, participants would be increasingly likely to expect that a URM child will grow up to be a doctor or a scientist (H3b).

Our hypotheses and data analytic plan were pre-registered on Open Science Framework (OSF). (https://osf.io/rg4ab/?view_only=99f0cf41b0684f6cbd188db2a326d2ff).

Methods

Participants

Participants ($N = 842$, 431 boys, 415 girls, 15 other) were children from ages 7 to 12 ($M_{age} = 9.70$ years, $SD_{age} = .97$) from the Mid-Atlantic region of the United States. The participant sample was 37 % White/European American, 21 % Multiethnic or other ethnic or racial group, 16 % Asian American, 14 % Latine, 12 % Black/African American. Participant age, gender, and racial and ethnic identity was determined by parental report. The sample was recruited from six public elementary schools with a range from low-middle to high-middle income as well as a mean of 25.7 % of students receiving free or reduced-price meals. None of these schools had an ethnic or racial numeric majority group that comprised more than 62 % of students. The percentage of White students in each school ranged from 18 % to 61.6 %, such that some schools had a White numeric majority, some schools had a Latine numeric majority, and other schools did not have a numeric majority of any single racial or ethnic group.

Procedure

This project was approved by the Institutional Review Board [#1093717-16] at the University of Maryland, College Park. All children received written parental consent to participate and gave verbal assent prior to administration of the study. When participants

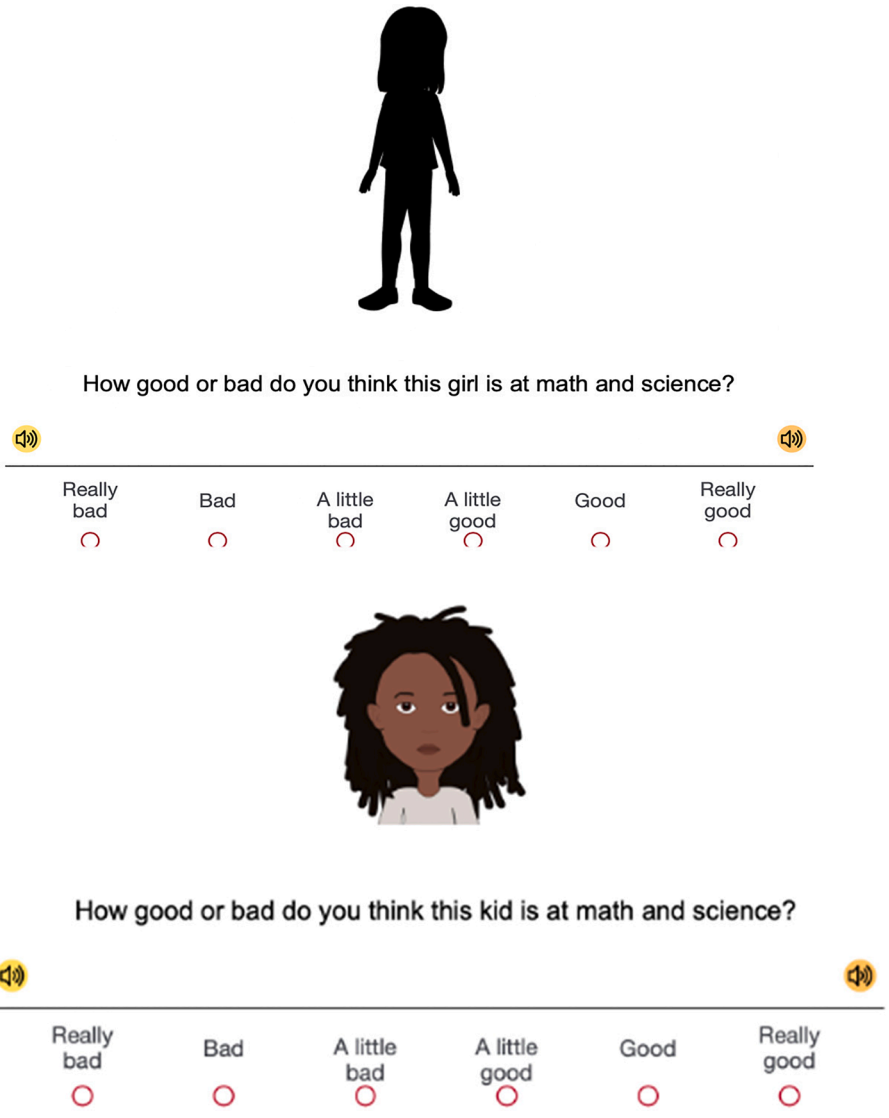

Fig. 1. Math and Science Competence Beliefs Item for Gender and Race.
Note. The first picture depicts the item for Girls and the second picture depicts the item for Black peers. Pixton characters, used with permission.

returned their parental consent form, they received a small prize (regardless of whether their parents consented or did not consent to their participation). The parental consent rate was 80.9 %.

A 30-minute survey was administered to children using Qualtrics. The survey was completed individually by children in a supervised classroom environment in which a researcher was present to give instructions and answer children's questions as needed. We evaluated children's beliefs about math and science competence of (1) girls, as well as (2) URM peers. We also assessed children's expectations about STEM occupations (specifically a doctor and a scientist) by having children select who they expected to grow up to be a doctor or a scientist using images of children of different genders and race-ethnicity.

Measures

Math and science competence beliefs. Participants' math and science competence beliefs were accessed by items adapted from Liben and Bigler (2002) that asked participants to indicate "How good or bad do you think this child is at math and science?" for peers from both target groups (see Fig. 1). We used realistic animated characters rather than photos of children. There are advantages and disadvantages to both forms of stimuli. Limitations of the use of photos include that photos are copyrighted and expensive to use for publications in journal outlets. Additionally open-use photo databases for researchers often have very limited numbers of photos based on age, racial or ethnic identity and/or facial expression. Thus, we used animated pictures as illustrated in Fig. 1.

Participants were asked about their math and science competence beliefs separately with (1) a girl character, (2) a Latine child and (3) a Black child. The items depicting the Latine and Black children were gender matched, such that participants all saw a character which matched the gender they selected at the beginning of the survey (e.g., a girl participant who selected "girl" as their gender at the beginning of the survey, would only see girl characters for the Latine and Black items). Participants who selected "other" for gender were randomly assigned to see either boy or girl characters for these items (< .01 %). By having participants view their own gender for these items, we aimed to minimize the degree to which participants attend to the gender of the stimulus, as they saw a series of questions about children of different races, all of their same gender. This gender-matching approach is consistent with many studies in the field and with prior literature on this general topic (Cooley et al., 2019; Elenbaas et al., 2022; Killen et al., 2022) which use illustrated vignettes to investigate children's social cognition about different social groups.

Participants responded on a 6-point Likert-type scale (1 = *really bad*, 6 = *really good*). The two individual items for a Latine peer and a Black peer were averaged across the depicted racial/ethnic group memberships to create a composite measure of children's math and science competence beliefs for URM children (Cronbach's $\alpha = .77$). Thus, we used two separate math and science belief outcomes: math and science competence beliefs for girls, and math and science competence beliefs for children who are part of an underrepresented minority (URM) in STEM.

STEM occupation expectations. Participants' STEM occupation expectations were measured by items adapted from Liben and Bigler (2002) that asked participants to select which single child from a set of eight children that they thought would grow up to be a doctor or a scientist. The options depicted a boy and a girl from each racial group: Asian, Black, Latine, and White (Fig. 2). For analyses using models that focused on the target group of girls, the eight response options were collapsed to be binary, such that girl = 1 and boy = 0. For models that focused on the target group of URM children, the eight response options were collapsed to be binary, such that Black or Latine = 1 and White or Asian = 0. This collapse grouped responses that selected children from a racial or ethnic group historically well represented in math and science (Asian and White), and those that selected children historically underrepresented in math and science (Black and Latine).

Covariates. Participant age was treated as a continuous variable. Participant gender was coded as girl or boy. For the 15 participants who selected the "other" gender category, they were randomly assigned to either the "boy" or "girl" condition, as to retain their data in the analyses. Due to the small number of participants in the "other" gender category in the present sample (1.7 %), there was insufficient power to retain them as a separate gender group in analyses. Participant ethnicity and race were coded as Asian, Black, Latine, White, or Multiethnic/Multiracial/Other.

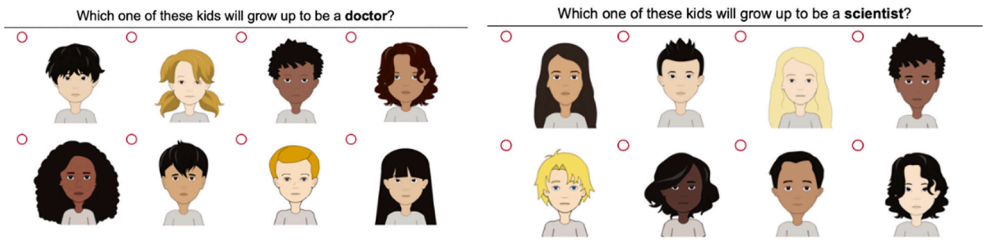

Fig. 2. Math and Science Competence Belief Items Note. Pixton characters, used with permission.

Data analytic plan

Analyses were conducted using R statistical software (Version 4.3.2, R Core Team, 2023).

Girls as target group. To test hypotheses regarding participant beliefs and expectations about girls (H1), we ran binomial logistic regression models with math and science competence beliefs, participant race, age, gender, and a gender × math and science competence beliefs interaction as likelihood predictors of expectations of girls' occupations. We ran separate models for predictions of girls being doctors and predictions of girls being scientists.

To test the hypothesis that participants would be more likely to expect girls to be a doctor than a scientist (H2), we conducted a repeated measures ANCOVA predicting girl occupation expectations by age, gender, and race, with repeated measures on the occupation type (doctor versus scientist).

URM as target group. To test hypotheses regarding the impact of math and science competence beliefs about URM children on participant occupation predictions for URM children (H3), we ran a series of binomial logistic regression analyses. In these analyses, math and science competence beliefs about URM children, participant race, age, gender, and an interaction of race × math and science competence beliefs about URM children predicted expectations of URM children's occupations. This process was conducted separately for the outcome measures of predictions of URM children becoming doctors and predictions of URM children becoming scientists.

We included participant gender and race in every model, given the extant stereotypes regarding both these identities are relevant to stereotypes about math and science competence and STEM occupations. For each model, we tested the most complex model first, including the hypothesized interactions. If interactions were not significant, we removed the interaction from the model and tested the simpler model. Final models were those with the lowest AIC.

Results

Expectations that a girl will be a scientist or doctor

For our hypotheses regarding the effect of math and science competence beliefs about girls on expectations that a girl will grow up to be a scientist and doctor (H1), as well as the effect of gender and age (H1b), we conducted separate models for scientist and doctor expectations. We did not find a significant gender by competence beliefs interaction in either model (*ps* > .69) (H1a), nor a significant effect of age on expectations for a girl to grow up to be a scientist or doctor in either model (*ps* > .7) (H1b). Therefore, we examined a main effects model. For expectations about a girl growing up to be a scientist, we found a main effect of math and science competence beliefs about girls ($B = .16$, $p = .029$, $OR = 1.18$) and of gender ($B = .87$, $p < .001$, $OR = 2.39$), such that overall, regardless of

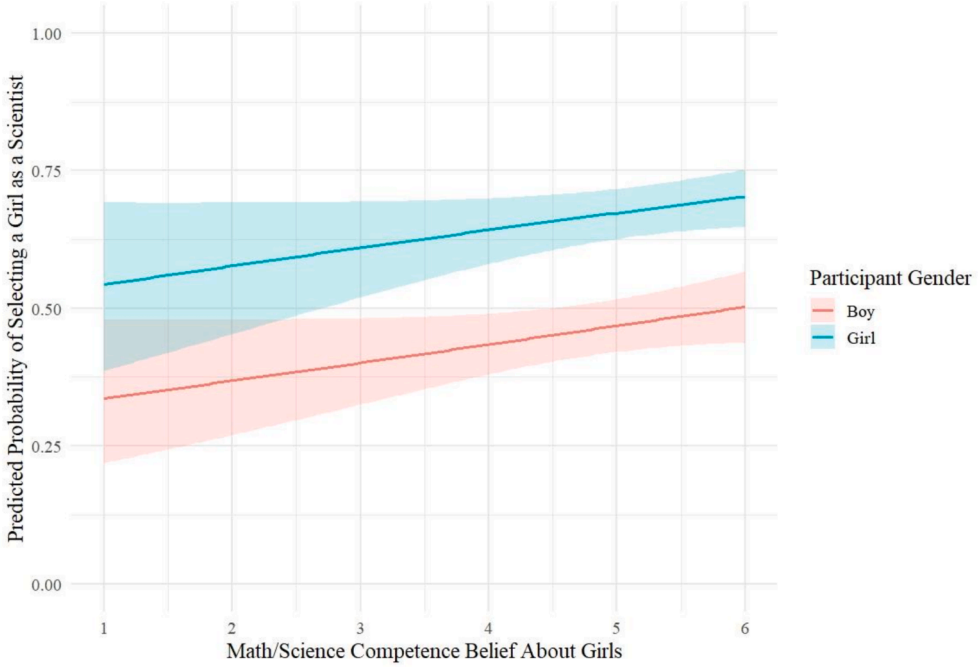

Fig. 3. Expectations For a Girl to Be a Scientist by Participant Gender and Math/Science Competence Beliefs About Girls.
Note. Higher math and science competence beliefs about girls was associated with a higher predicted probability of selecting a girl as a scientist ($B = .16$, $p = .029$, $OR = 1.18$). Girls showed a higher likelihood of selecting a girl to be a scientist than did boys, across all levels of competence beliefs.

competence beliefs, girls were more likely than boys to select a girl to be a scientist (Fig. 3). For expectations about a girl growing up to be a doctor, we found a main effect of math and science competence beliefs about girls ($B = .20$, $p = .01$, $OR = 1.22$; Fig. 4) and of gender ($B = .72$, $p < .001$, $OR = 2.05$), such that higher math and science competence beliefs predicted a higher likelihood of selecting a girl to grow up to be both a scientist and a doctor for all participants, but at every level of competence beliefs, girls were more likely than boys to select a girl to grow up to be in the STEM profession. This partially confirmed our H1.

Regarding our hypothesis that children would be more likely to expect a girl to grow up to be a doctor than a scientist (H2) and that this effect would be stronger for boys (H2a), as predicted, we found a main effect of the repeated measure for occupation ($F(1, 791) = 36.02$, $p < .001$, $\eta_p^2 = .04$; Fig. 5), confirming H2. A higher proportion of participants selected a girl as most likely to grow up to be a doctor (.69) than selected a girl as most likely to grow up to be a scientist (.56). We did not find a gender by occupation interaction (H2a). These results partially confirmed our hypotheses.

Occupation selections differ from chance by participant gender

We conducted confirmatory χ^2 goodness-of-fit tests to examine if the proportion of each participant gender group selecting a girl to be each profession differed significantly from chance. In this case, chance was.5, as participants selected from 8 options, 4 of which were girls. These confirmatory analyses provided additional context for our findings, in addition to our preregistered analytic plan. Both girls ($\chi^2(1) = 129.02$, $p < .001$) and boys ($\chi^2(1) = 30.36$, $p < .001$) selected a girl as a doctor significantly more than chance. Girls also selected a girl to be a scientist significantly more than at chance ($\chi^2(1) = 50.58$, $p < .001$). However, boys were at chance in selecting a girl to be a scientist ($\chi^2(1) = 2.55$, $p = .11$). Thus, this reflects our expectations that children's perspectives reflect previous findings that women are more represented in the health care professions than are men, and that children recognize this (Charlesworth & Banaji, 2019). See Table 1.

Expectations that an URM child will be a scientist or doctor

For our hypothesis regarding the effect of math and science competence beliefs about URM peers for expectations that a URM child will grow up to be a scientist and doctor (H3), as well as the effect of participant race (H3a) and age (H3b), we conducted separate models for scientist and doctor expectations. Below, we have organized results below by the predictors for each model.

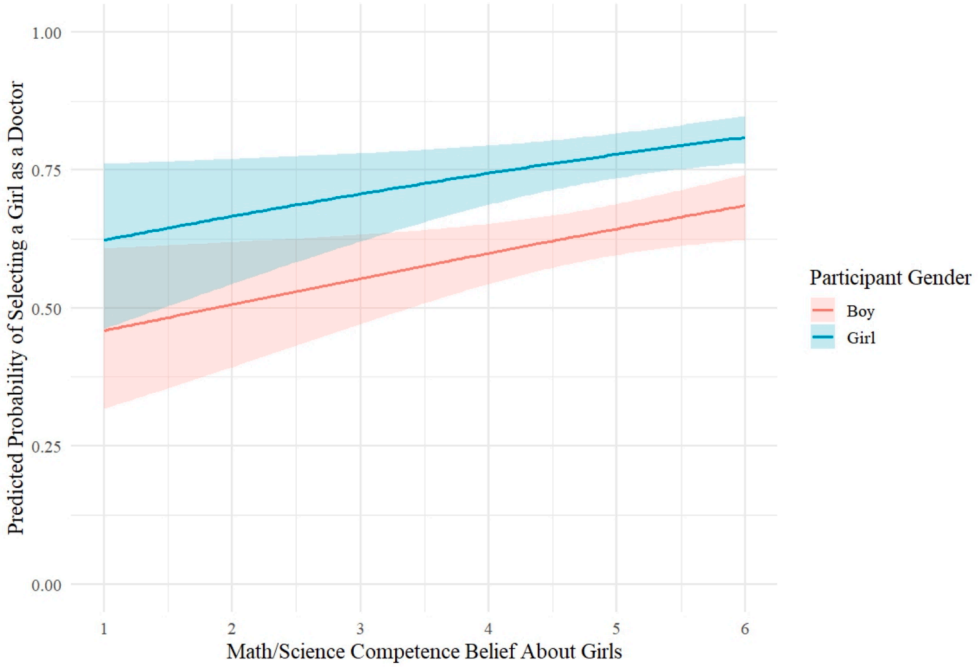

Fig. 4. Expectations For a Girl to Be a Doctor by Participant Gender and Math/Science Competence Beliefs About Girls.
Note. Higher math and science competence beliefs about girls was associated with a higher predicted probability of selecting a girl as a doctor ($B = .20$, $p = 01$, $OR = 1.22$). Girls showed a higher likelihood of selecting a girl as a doctor than did boys, across all levels of competence beliefs.

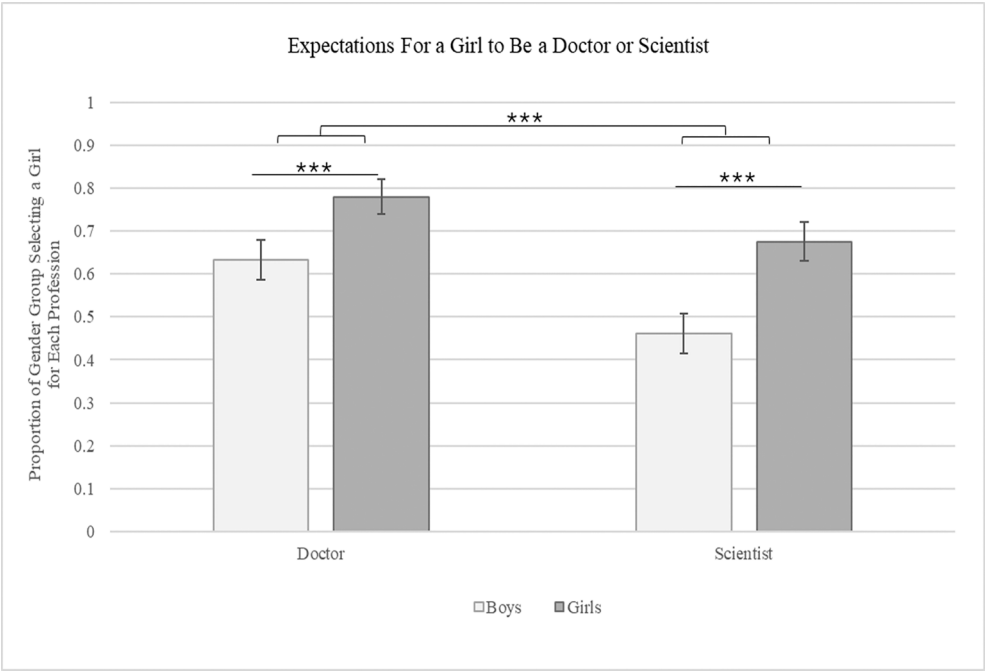

Fig. 5. Proportion of Participants Expecting a Girl to be a Doctor and Scientist, by Participant Gender.
Note. N = 842. *** p < .001.

Table 1
Observed Proportion of Participant Gender Groups Who Select a Girl for High-Status Occupations.

	Doctor	Scientist
Participant Gender: Boy	.63***	.46
Girl	.78***	.67***

Note: Significance values above indicate a χ^2 goodness-of-fit test significant difference from chance (.5) within each participant gender group. $N = 842$. *$p < .05$, ***$p < .001$.

Main effect of competence beliefs

For expectations about a URM child growing up to be a doctor, we found a main effect of math and science competence beliefs about URM peers ($B = .40$, $p < .001$, $OR = 1.50$), such that higher competence beliefs predicted a higher log likelihood of selecting a URM child as who one would expect to grow up as a doctor, confirming H3. In contrast, we did not find a main effect for math and science competence beliefs about URM peers on participants' expectations that a URM peer would be a scientist (H3).

Effects of participant race

For children's expectations that a URM child would grow up to be a doctor, we found a main effect of race, though we did not find a race by competence belief interaction (H3a). We explored this effect through Bonferroni adjusted follow-up pairwise comparisons, which revealed that Asian participants were less likely than either White participants ($p = .02$) or Black participants ($p = .001$) to expect a URM to be a doctor (see Fig. 6). For children's expectations that a URM child would grow up to be a scientist, we also did not find a race by competence beliefs interaction (H3a).

Effect of participant age

As expected, we found a main effect of age ($B = .18$, $p = .018$, $OR = 1.20$), such that with age, children were more likely to expect a

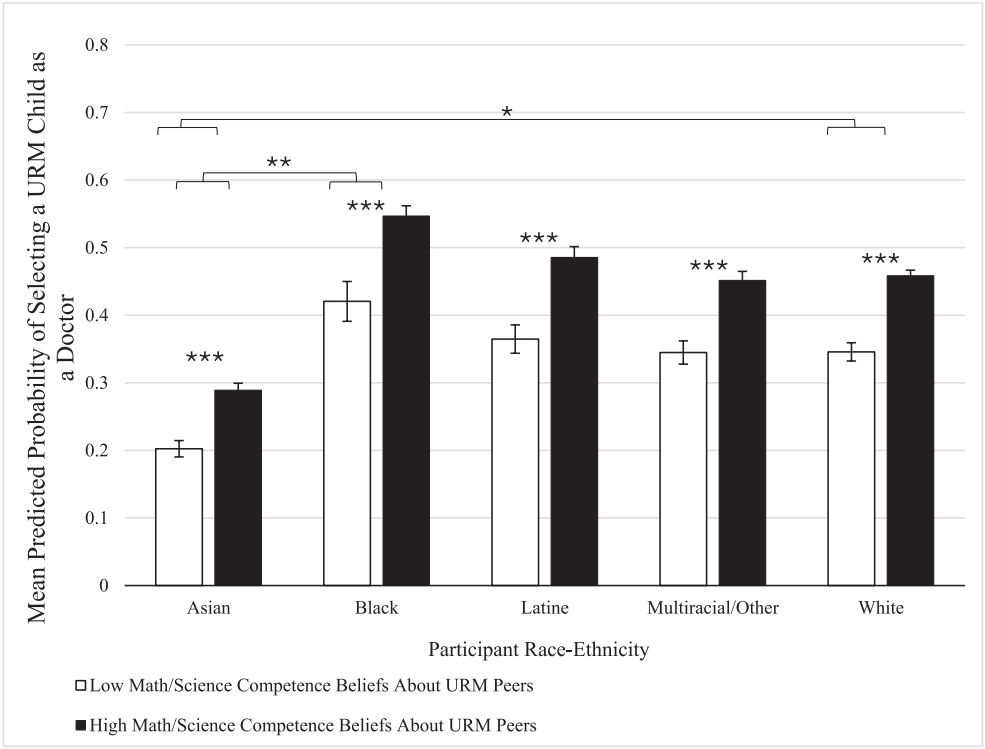

Fig. 6. Mean Predicted Probability of Participants Selecting a URM Child to be a Doctor, by Participant Race Note: Low and high levels of math and science competence beliefs about URM peers are based on mean (4.82) split N = 830. * p < .05, **p < .01, ***p < .001.

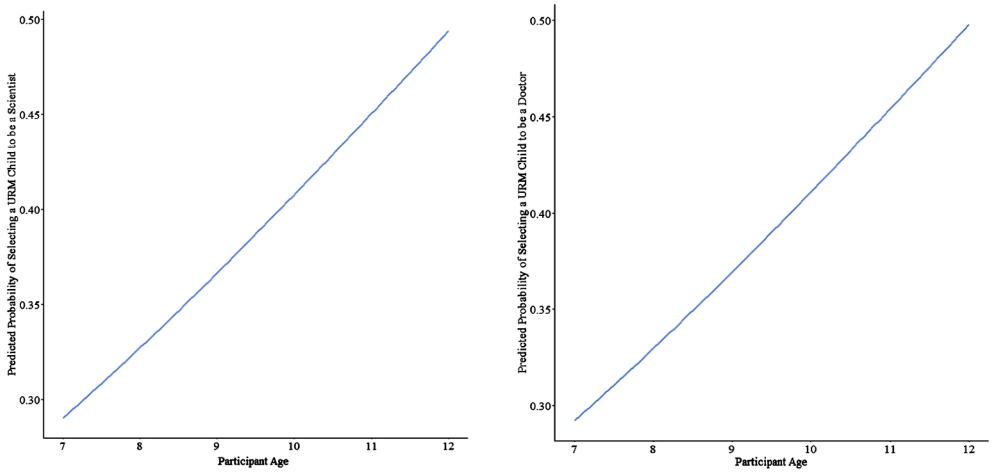

Fig. 7. Predicted Probability of Selecting a URM Child to be a Scientist and Doctor, by Age.
Note. Predicted probability of participants selecting an URM child as a scientist (left) and doctor (right) based on age, $N = 830$.

URM child to be a doctor, confirming H3b. For expectations about a URM child growing up to be a scientist, we also found a main effect of age ($B = .20$, $p = .008$, $OR = 1.22$). With age, children were more likely to select an URM child as who they expected to grow up to be a scientist, confirming H3b (See Fig. 7).

Occupation selections differ from chance by participant race

To provide additional context for our findings, we also conducted χ^2 goodness-of-fit tests to examine if the proportion of each participant racial and ethnic group selecting a URM child to be each profession differed significantly from chance. Chance, in this case, was.5, as participants selected from 8 options, 4 of which represented a URM child (a Black boy and girl and a Latine boy and girl). Consistent with our hypotheses, Asian ($\chi^2(1) = 31.25$, $p < .001$), Multiracial/Other ($\chi^2(1) = 6.61$, $p = .009$), and White ($\chi^2(1) = 8.95$, $p = .002$) participants all selected a URM child as a ***doctor*** significantly below chance, while the observed proportion of Black and Latine children selecting a URM child as a doctor did not differ significantly from chance, potentially reflecting a lack of bias (See Table 2).

For expectations about who would grow up to be a ***scientist***, Asian ($\chi^2(1) = 7.56$, $p = .005$), Latine ($\chi^2(1) = 7.71$, $p = .005$), and White ($\chi^2(1) = 15.31$, $p < .001$) children all selected a URM child significantly below chance, while Black and Multiracial/Other participants' selections did not differ significantly from chance, potentially reflecting a lack of a bias. Thus, Black and Latine participants are just as likely to select a URM child as a White or Asian child to be a doctor, which may indicate the absence of a bias. In contrast, White, Asian, and Multiracial participants were more likely to select a White or Asian child to be a doctor.

Discussion

Developmental, educational, and psychological research has demonstrated that student interest and motivation in science, technology, engineering, and math (STEM) subjects declines beginning as early as elementary school (K-5), and this is particularly evidenced for women and underrepresented ethnic/racial minority (URM) students (Brantlinger, 2018; Master, 2021; Wang & Degol, 2017). In this study, we found that not only do low competence beliefs about math and science for girls and URM students exist, but these attitudes are linked to the extent to which children view their peers as likely to have future high-status occupations that reflect STEM abilities: a doctor and a scientist. On the flip side, participants who did not display negative expectations about math and science competence beliefs were more likely to expect girls and URM students to have high-status STEM occupations as adults.

The relation between children's math and science competence beliefs about girls and URM students with their expectations about STEM-related future occupations is important, as low expectations about math and science competence for girls and URM students are communicated through implicit and explicit messages and may impact their future STEM interests and opportunities. As predicted, based on the SRD model, judgments and attitudes about group norms, such as expectations about who is likely to be good at STEM-related activities or to follow career paths, varied depending on the group identity of the target groups as well as participants' own identity. There were novel findings in this study for beliefs and expectations based on participants' age, gender, and racial and ethnic backgrounds.

Gender Beliefs and Expectations. We found that higher beliefs in girls' math and science competence predicted a higher likelihood of selecting a girl to grow up to be both a scientist and a doctor. This finding demonstrated a significant link between beliefs about STEM competence and expectations about future STEM occupations. An implication is that increasing children's awareness that anyone can become a scientist or a doctor may also reduce exclusionary messages about who has the potential to engage in STEM-related activities.

This finding is relevant not only to children's beliefs about others but also about themselves. When children view their own math and science competence as limited, they may lose motivation to become engaged in STEM-related activities, creating a vicious cycle. Becoming disengaged from math and science activities in childhood makes it more difficult to gain the skills to do well in high school, higher education, and eventually the workforce. Eccles and Wigfield's Expectancy-Value Theory (Eccles & Wigfield, 2024) has posited that achievement-related choices are motivated by a combination of students' expectations for success and their perceived value of an academic subject area. Children are more likely to pursue an activity if they expect to do well and value the activity. Situated expectancy value theory also posits that competence beliefs and subjective values compound on each other to influence students' achievement and academic choices, which suggests that these constructs interactively influence academic outcomes. This has

Table 2
Observed Proportion of Participant Race Groups Who Select a URM Child for High-Status Occupations.

	Doctor	Scientist
Participant Race: Asian	.25***	.38**
Black	.50	.41
Latine	.43	.36**
Multiracial/Other	.40**	.45
White	.41**	.39***

Note: Significance values above indicate a χ^2 goodness-of-fit test significant difference from chance (.5) within each participant race group. $N = 830$. *$p < .05$, **$p < .01$, ***$p < .001$.

implications for career choices, given that expectations about math and science competence are related to predictions about future occupations.

Overall, girls were more likely than boys to expect a girl would grow up to be both a scientist and a doctor, demonstrating that both high-status occupations reflected gender-based biases for 7 – 12 year old boys. While this could be interpreted as merely a gender in-group preference, viewed in the context of prior literature showing the presence of gender stereotypes about STEM interest form early in childhood (Master et al., 2021), it may be that this gender difference in occupation expectations reflects a consequence of other gender stereotypes children hold about STEM, including interest and competence. Further, a higher proportion of participants selected a girl as most likely to grow up to be a doctor than selected a girl as most likely to grow up to be a scientist, reflecting a gender-based bias about one area of STEM but not another area. Even as young as 7 – 12 years of age, children make distinctions between different types of STEM-related occupations, which confirms findings reported by Rosenzweig and Chen (2023) in their survey with adolescents. Future research regarding children's reasoning and explanations about why girls are more likely to be doctors than scientists would reveal the basis for this distinction and would shed light on the source of this expectation.

Beliefs about URM students and expectations about becoming a doctor

As predicted, higher math and science competence beliefs predicted a higher likelihood of selecting an URM child as likely to grow up as a doctor. We did not find that the race of the participant moderated the effect of competence beliefs, though with age, children were more likely to expect a URM child to be a doctor.

These findings reveal that reducing negative STEM-related competence beliefs about URM peers would help to encourage expectations that anyone can become a doctor. This is particularly important given that Asian, Multiethnic, and White children were below chance at expecting a URM child to become a doctor, reflecting a partial confirmation of our hypothesis. More research is needed to understand the ways contributors to these differential expectations may differ by racial group. One factor may be parental messages. A recent review by Perry et al. (2025) regarding racial socialization addressed how parents from different racial backgrounds contrastingly view their role when teaching children about prejudice. For instance, interviews with parents in Asian immigrant households reveal that parents may feel threatened by the bias they experience, in contrast to those from other minority backgrounds. Asian parents have been documented to downplay the presence of racial prejudice to their children. Likewise, White children are less likely to learn about racial prejudice from their parents, compared with other minority groups (Perry et al., 2025). Research has demonstrated that when children are unaware of structural inequalities, they are more likely to ascribe the cause of an inequality to issues of merit (Rizzo & Killen, 2020). Thus, being less aware of societal racial prejudice may contribute to Asian and White children *assuming* that their experience observing few Black and Latine doctors (Association of American Medical Colleges, 2025) is due to a lack of merit within these groups. This perspective may reinforce biased expectations of who would grow up to be a doctor. However, research has also demonstrated the harmful aspects of the "model minority myth" that positions Asian children as expected to excel in STEM subjects (McGee et al., 2017; Trytten et al., 2012). Further research is necessary to understand the role of parental messages in different racial groups, including the model minority expectation, in children's expectations of high-status occupations based on race and ethnicity.

Beliefs about URM students and expectations about becoming a scientist

With age, children were more likely to select an URM child for whom they expected to grow up to be a scientist. Interestingly, there were no effects of math and science competence beliefs about URM peers, nor a race by competence beliefs interaction for expectations about URM children becoming scientists. Younger children were less likely to select a URM child than older children were, consistent with prior research demonstrating the presence of STEM stereotypes from early in childhood (Master et al., 2021; Miller et al., 2018). The finding that older children were less likely to reinforce stereotypic expectations about URM children as scientists reflects other research from the SRD perspective that shows children often become more aware of social inequalities with age (Elenbaas et al., 2020). This developmental shift indicates the malleability of stereotypes in middle childhood, suggesting the importance of curriculum programs focusing on all students' potential to excel in STEM subjects and careers could begin in early childhood and elementary school.

Limitations and future directions

These findings warrant future research to better understand the larger context of the development of STEM-related biases. First, future research should adapt measures of competence beliefs to separately assess children's beliefs about math competence *and* science competence. It may be that children have differential stereotypes about these two domains, and more specific measures could elucidate this more clearly. To understand the implications for these different stereotypes, future research should also compare children's stereotypes about a wider range of STEM occupations, specifically, health sciences occupations, as to build upon our finding that children expect girls to be a doctor, more than to be a scientist. This future research would also add understanding about children's stereotypes and expectations regarding health science occupations, which may simultaneously be considered STEM occupations (where women are underrepresented, as a whole) *and* HEED occupations (where women are overrepresented, as a whole). Further, adding assessments that measure children's reasoning for their judgments would be fruitful to determine why there were different expectations for who can be a doctor or a scientist. We speculate that participants may have been more likely to select a girl to grow up to be a doctor than to be a scientist because children have more opportunity to observe women in health professions, such as a

pediatrician or family physician, than in physical science (chemistry, physics) areas.

Other areas for future inquiry include addressing the role of parental messages and probing the sources of children's stereotypes about women in STEM professions. Studying the role of parental messages about whom children think their parents would select to be a doctor or a scientist or, more generally, assessing whether children support or reject parental messages about STEM-related activities based on gender or race and ethnicity, would be fruitful (see Van de Rozenberg et al., 2024). Research on children's evaluations of interracial peer friendships has shown that children view same-race preferences from parents more positively than from peers (Luken Raz et al., 2025), suggesting that parental messages that focus on ingroup bias may be more difficult for children to challenge than those from their peers.

Regarding the role of race and ethnicity, more research needs to be conducted with a wider range of target groups to unpack the relationship between participant race and ethnic identity and STEM-related attitudes and expectations about future occupations. Participants were asked to make judgments about characters depicted as White, Asian, Black, and Latine. Multiple target groups should be depicted in future research, including Multiethnic, and other groups that reflect regional differences in the area of inquiry. Multiple target groups would help interpret the findings and shed light on the complex relationship between a target group and a participants' group identity in the area of STEM biases and expectations. Further, more research is needed to examine this topic in non-U.S. and non-Northern Europe countries to understand what types of STEM-related biases and equality judgments are generated by children when responding to STEM-focused social cognitive assessments (Musso et al., 2022). This is particularly important for contributing to a global science (Singh et al., 2024). Additionally, the current study assessed children's beliefs and expectations for girls and URM peers in separate analyses, rather than examining hypotheses regarding children's differential expectations about URM peers who were girls or boys. Future research should take a more intentional approach to examining intersectionality by systematically varying gender and racial-ethnic identity to explore how children weigh both gender and racial-ethnic group membership in their STEM-related attitudes and expectations about future occupations.

Additionally, in the current study, children who indicated "other gender" ($n = 15$ which represented less than 2 % of the overall sample) were randomly assigned to view a "boy" or "girl" protocol, due to their relatively small number and to retain these perspectives within the greater sample. Future research should work to identify study design and data analytic strategies that are inclusive of an array of gender identities while exploring children's gender stereotypes, which often reflect a binary conceptualization of gender.

Conclusion

The novel findings of this study revealed significant relationships between math and science competence beliefs and expectations about who is likely to grow up to work in a STEM-related field as a scientist or doctor. The results from this study illustrate the need for school-based curricula programs to reduce STEM stereotypes and enable all students to experience a sense of belonging and identity within STEM, as well as to engage children in STEM-related activities beginning in early childhood. Societies benefit and flourish when obstacles are removed which inhibit individuals from contributing their skills and talents to the many varied fields within this arena.

CRediT authorship contribution statement

Melanie Killen: Writing – review & editing, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Elise M. Kaufman:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kate V. Luken Raz:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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