Acta Psychologica 233 (2023) 103845

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

The impact of visualizing the group on children's persistence in and perceptions of STEM

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ARTICLE INFO

Keywords:
STEM motivation
Gender gap in STEM
Development
Stereotypes
Early childhood

ABSTRACT

Women are underrepresented in STEM fields across the world. We investigate a perceptual mechanism that may contribute to this gender disparity beginning in early childhood. We explore how visual information about the gender composition of a group of scientists impacts children's persistence on a STEM task and their evaluations of group members. One hundred sixty-six 4- to 6-year-old children viewed one of four groups of scientists: all-male, all-female, a lone female among all-males, or a lone male among all-females. Whereas children's persistence on a STEM task did not change across conditions, their trait judgments did. Children judged the all-male and all-female group scientists as "hardworking," but judged the lone female scientist as "smart." However, they were as likely to judge the lone male scientist as "smart" as to judge him "hardworking." The role of group visualization as a learning mechanism impacting children's perceptions of scientists as early as the preschool years is discussed.

1. Introduction

Groups of scientists in STEM fields are largely homogeneous and disproportionately composed of males (National Science Foundation & National Center for Science and Engineering Statistics, 2021). This underrepresentation of women in STEM fields remains the norm in the United States, especially in physics, computer science, and engineering (National Science Foundation & National Center for Science and Engineering Statistics, 2021), despite women achieving better grades in science throughout school (Voyer & Voyer, 2014). Much of the research on this gender gap in STEM in the United States has focused on older children and adults (e.g., Bagès et al., 2016; Bagès & Martinot, 2011; Cheryan et al., 2009). However, a growing body of research has begun to explore factors impacting STEM motivation in early childhood, suggesting that even as early as the preschool years, children are receiving and responding to messages about the individuals who belong in STEM and those who do not (e.g., Bian et al., 2017; Lei et al., 2019; Rhodes et al., 2019; Rhodes et al., 2020). This paper extends the work on STEM gender disparities by examining how visual cues regarding the gender composition of a group of scientists influence four- to six-year-old children's STEM motivation.

Prior research indicates a few possible learning mechanisms that may impact children's early STEM motivation. One such mechanism is the belief that innate brilliance, rather than effort, is required to succeed in STEM fields (e.g., Chestnut et al., 2018). Another learning mechanism is associated with the language to which children are exposed. For example, five- to seven-year-old children's science interest, feelings of self-efficacy in science, and persistence on a science task increase when an adult describes the task in terms of actions rather than in terms of group identity (Lei et al., 2019; Rhodes et al., 2019). One interpretation of this finding is that female children may not feel a sense of belonging to the group "scientists" and that this early sense of non-belonging may negatively impact motivation in science across the lifespan (Rhodes et al., 2019). Indeed, merely belonging to a group has been shown to increase young children's interest and participation in science tasks (Master, Cheryan, & Meltzoff, 2017; Master, Cheryan, Moscatelli, & Meltzoff, 2017; Master & Walton, 2013). In addition to being impacted by a sense of belonging, young children also use information about groups (e.g., gender) to make inferences about how other group members might behave (e.g., Kinzler et al., 2011; Spelke & Kinzler, 2007). Such inferences influence self-perceptions and may impact children's early STEM learning and motivation across the lifespan (e.g., Master, 2021).

The current study aims to investigate a related learning mechanism

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https://doi.org/10.1016/j.actpsy.2023.103845
Received 1 August 2022; Received in revised form 23 December 2022; Accepted 20 January 2023

that could impact the gender gap in STEM, exploring how *visual* cues about who belongs in STEM influences children's motivation. Specifically, we address how the relative lack of women in science may impact young children's motivation and participation related to STEM, gender, and perceptions of brilliance. For example, if children see that only four of the last 219 Nobel Prize winners in Physics were women, how might this gender disparity impact children's persistence on a STEM task and their perceptions of male versus female scientists?

Before examining the current study, we briefly review literature surrounding attribution theory and science motivation, language as a mechanism to reinforce STEM stereotypes, and children's understanding of group context.

1.1. *Role models, attribution theory, and science motivation*

A recent paper from Gladstone and Cimpian (2021) systematically reviewed the literature on role models in the domain of STEM. They found that some STEM role models are more effective than others. Particularly relevant to the current study, the review found that performance and motivation generally increased when participants were exposed to role models who were competent but not exceptional (e.g., Lockwood & Kunda, 1997) and who belonged to an underrepresented group in STEM (e.g., a female role model; Bagès et al., 2016; Gladstone & Cimpian, 2021). Notably, the review found that the vast majority of research on role models in STEM examine older children and adults, suggesting a gap in knowledge about how young preschool age children respond to role models in STEM. However, researchers are beginning to focus on early childhood as a time when introductions to STEM role models may impact children's motivation in STEM. For example, one recent study with four- to seven-year-old children found that when young girls pretend to be a female role model, they persist longer at a science task and report greater feelings of self-efficacy than if they are not introduced to the role model at all (Shachnai et al., 2022). In the current study, we introduce preschool age children to an individual scientist (who could be viewed as a potential STEM role model), situate the scientist among a group of peers, and investigate how the gender composition of the group impacts children's persistence on a STEM task and perceptions of the individual scientist.

Our study draws on attribution theory as a framework for understanding how and why visualizing an individual scientist among a group of scientists varying by gender could impact children's motivation, persistence, and perceptions in STEM. Within the framework of attribution theory, children's motivation and persistence can be influenced by how they explain the cause of success and failure (Graham, 2020; Weiner, 1985). Within Western culture, Graham (2020) notes that ascriptions of ability and effort are the most typically perceived causes of success and failure. Attribution theory can be used to consider how people attribute success and failure in themselves as well as how people attribute the success and failure of others (Graham, 2020). In addition to a role model's features, such as competence and success, children's attributions of why the role model is competent and successful may impact their motivation in STEM learning situations. For example, if children attribute a role model's success to effort, which is a controllable, internal, and unstable factor, then success in STEM may seem attainable. However, if children attribute a role model's success to ability, which is an uncontrollable, stable factor, then success may seem unattainable (see Gladstone & Cimpian, 2021). Prior work with fifth-grade children has used a motivational framework to consider how children's attributions and ascriptions of a role model's success relates to their own math performance (Bagès & Martinot, 2011). When children were presented with a role model whose math success was attributed to hard work rather than ability or unexplained factors, their math scores were significantly enhanced (Bagès & Martinot, 2011). The current paper examines young children's motivation in the face of an initial failure on a science task and their causal ascriptions of an individual scientist's success given their placement within a group of same or different gender scientists.

1.2. *Language as a learning mechanism that reinforces STEM stereotypes*

In early childhood, some research advocates for diversifying representations of people in STEM, rather than perpetuating narrow stereotypes about who belongs in STEM (e.g., by not portraying every computer scientist as a geeky man; Cheryan et al., 2015). Additionally, research indicates that girls' interest and self-efficacy in STEM can be increased through experience with that STEM field (e.g., through programming experience; Master, Cheryan, Moscatelli, & Meltzoff, 2017).

Recent work highlights language as a powerful learning mechanism through which gender stereotypes are reinforced and transmitted to young children. Although much of the research surrounding stereotypes in STEM has involved adults (e.g., Cheryan et al., 2017; Smith et al., 2007; Spencer et al., 1999), from an early age, young girls are also impacted by stereotypes related to STEM fields (e.g., Cvencek et al., 2011; Master, 2021). Indeed, strongly held negative stereotypes about women in STEM negatively impact girls' performance in math and computer science (Huguet & Regner, 2007; Master et al., 2014; Master, Cheryan, & Meltzoff, 2017). Prior work has shown that these negative stereotypes are malleable. One avenue for changing negative STEM stereotypes is through encouraging a growth mindset (i.e., the belief that intelligence can change over time) rather than fixed mindset (i.e., the belief that intelligence is stable over time; Dweck, 2008). For example, five- to twelve-year-old children who received a growth mindset intervention (compared to a control group who received no intervention) were less likely to endorse gender stereotypes about STEM than their peers, despite both groups reporting equal levels of stereotype awareness (Law et al., 2021). This finding suggests that mindset can be changed through a short intervention and that a change in mindset is linked to reducing negative stereotypes in STEM. Additionally, the *impact* of negative stereotypes is malleable: diversifying representations of people in STEM, providing children with hands-on STEM experience, encouraging a growth mindset, and exposing children to hardworking role models have all been shown to increase children's motivation and performance in STEM (Bagès et al., 2016; Blackwell et al., 2007; Cheryan et al., 2015; Master, Cheryan, Moscatelli, & Meltzoff, 2017; Master & Walton, 2013).

Here, we focus on the language adults use to frame and discuss science as a malleable learning mechanism that can impact children's interest and motivation in STEM. For example, success in STEM is often falsely believed to derive from an individual's innate “brilliance,” a trait stereotypically attributed to boys and men (Chestnut et al., 2018). Girls are responsive to language that reinforces gender stereotypes in STEM; from as young as five years, girls are less likely than boys to choose a game for “really smart” people than a game for people who “work really hard” (Bian, 2017; Bian et al., 2017). Boys and girls have also been shown to prefer boys over girls in contexts where intellectual ability is emphasized, choosing boys significantly more than girls when asked to pick a team to play a “smart game” (Bian et al., 2018). Taken together, through their language, adults may shape and perpetuate children's perceptions that not only is brilliance in science innate to boys, but also that girls may not have the capacity to achieve this level of brilliance.

In the science domain, subtle linguistic cues also contribute to the maintenance of exaggerated beliefs about group membership. For example, girls persist longer found that girls persist longer at a STEM task if an experimenter described the task in terms of actions (e.g., “doing science”) rather than in terms of identity (e.g., “being scientists”), whereas boys' persistence was not affected by this linguistic difference (Rhodes et al., 2019). This research suggests that when presented with identity-focused language, children examine whether they could plausibly be members of the relevant group. In the current study, we extend this work to explore how visual cues might affect children's motivation on a STEM task. We predicted that exposing children to visual information about groups of scientists should activate children's conceptions of who belongs in science and specifically whether they could hold membership in STEM. Similar to action-focused versus identity-focused language, groups of scientists with more female members might motivate children to persist longer at a science task than groups of scientists with mostly male members.

1.3. Group context and the current study

Scientists as a group, especially scientists in computer science, physics, mathematics, chemistry, and engineering, are primarily male. Research indicates that young children use naturalistic group markers such as gender to make inferences about different groups (e.g., Spelke & Kinzler, 2007). A great deal of research shows that young children are sensitive to group consensus, taking this information into account when making inferences and imitating (Corriveau et al., 2009; Herrmann et al., 2013; Morgan et al., 2015);. Thus, we argue that the perceptual salience of a group's gender composition (e.g., a group of scientists who are male) may reinforce stereotypes suggesting that girls have a lower aptitude for STEM than boys, impacting girls' beliefs about their own abilities in science and ultimately discouraging them from pursuing STEM paths.

The current study investigated how children respond to visual information about groups of scientists that vary by gender composition. Here, we emphasized a single scientist and placed them within a group context that varies by gender composition. Children were then exposed to the visual information and then invited to play a science game and respond to trait attribution questions. We predicted that children would persist longer when exposed to an all-female group of scientists compared to an all-male group of scientists because, regardless of gender, children in that condition would be most likely to feel that they could potentially be part of the group of scientists (Rhodes et al., 2019). We also predicted that children who viewed groups of same gender (both all-female and all-male) scientists would persist longer than children who viewed the gender-imbalanced groups because they would view those groups as less likely to produce conflict than the strongly gender-imbalanced groups (Corriveau et al., 2009; Herrmann et al., 2013; Watson & Kumar, 1993).

We had no strong hypotheses about children's persistence in gender imbalanced groups where the individual scientist's gender differed from the other group members' genders. On the one hand, children might persist longer in the female/all-male condition, because girls might view the lone female scientist as inspirational, and boys might view the relative majority of boys to be motivational. Alternatively, children might view the lone female scientist as alienating and persist less in that condition than in the male/all-female condition where they might view a relative majority of girls as motivational. If children persisted equally as long in both conditions, this might indicate that they were less focused on the ratio of male to female scientists and more focused on the overall composition of the group (one exception among an otherwise homogeneous group).

To gather more information about children's trait attribution of the scientists, we also invited children to judge whether they thought the individual scientist was “smart” or “hardworking” and to justify their response (Bian et al., 2017). Based on prior work, we predicted that children would judge the female scientist from the all-female group as hardworking and that they would judge the male scientist from the all-male group as smart. However, we were uncertain about how children would judge the male and female scientists who were part of different gender groups. It seemed equally plausible that children might judge the male scientist within an all-female group as smart (due to stereotypes surrounding male brilliance in STEM) or that they might judge him as hardworking (due to the fact that he was part of a larger group that was different from him and therefore may have had to work hard to get there). Similarly, children who viewed the female scientist within the all-male group might view her as hardworking (due to stereotypes about women being less brilliant than men in STEM) or smart (due to the fact that she might have to be extremely brilliant to succeed).

2. Method

2.1. Participants

Participants included 166 children who ranged in age from 4;0 to 6;5 ($M = 60.4$ months, $SD = 7.3$). Children were recruited from an array of preschools in [location removed for review] (67 male). The study typically lasted about 5 to 10 min and children were tested in secluded locations in their classrooms. Children viewed one of four conditions: either a female scientist situated in a group of all-female scientists (All-Female), a male scientist situated in a group of all-male scientists (All-Male), a female scientist within a group of all-male scientists (Female/All-Male), or a male scientist within a group of all-female scientists (Male/All-Female). After viewing one of these scenarios, all children then played a science game about whether objects sink or float in water and answered a forced choice question about whether they thought the individual scientist was smart or hardworking. Children were evenly distributed across conditions: All-Female condition ($n = 41$), All-Male condition ($n = 43$), Female/All-Male condition ($n = 45$), and Male/All-Female condition ($n = 37$). This sample size, and specifically within-condition sample size, is in line with previous research utilizing Cox regression survival analysis to measure children's trial persistence (see Rhodes et al., 2019). Fourteen additional children were excluded from the final analysis because they failed the memory checks.

2.2. Procedure

2.2.1. Introductory phase

Children were randomly assigned to one of four conditions (All-Female, All-Male, Female/All-Male, or Male/All-Female) and presented with a slide show. The experimenter first introduced the target scientist and said, “This is Amy/Danny. Amy is a physicist, which means she is a *scientist*. Next, the scientist was shown in a science lab setting and the experimenter said, “You can see her here working on a physics project. She is one of the best scientists in this workplace and is very smart and works very hard.” The experimenter then introduced six other scientists, either all-male or all-female depending on condition, by saying, “These are the people that Amy works with every day. This is Alex. This is Duncan. This is Troy. This is James. This is William. This is Anthony. All of these boys are *scientists*. They are very smart and work very hard at their jobs.” We described the characters both as smart and as hardworking so that the characters might be viewed as competent but not unattainably so (consider Lockwood & Kunda, 1997). In the first introductory slide, the target character wore a pair of lab goggles to demonstrate that they were working on a project. However, in the other slides, the target character and surrounding characters were dressed in a simple shirt and pants. We intentionally did not dress target characters in stereotypical scientist clothing such as a lab coat so as not to contribute to children's potentially already existing stereotypes (see Chambers, 1983). Additionally, we refrained from giving the target characters stereotypically masculine or feminine clothing (e.g. baseball caps or dresses; blue or pink colors, respectively; see Fig. 1). The scientists were all white in an effort to focus children on gender as the most salient aspect of the group composition. Finally, the experimenter presented children with a slide showing the individual and group together, renaming them and reminding them that the characters are all scientists who work together (see Fig. 1).

2.2.2. Persistence task

In the domain of science, persistence in the face of failure, perceived failure, or a difficult task is a critical component of the scientific method. Prior work exploring young children's persistence has presented children with challenging or impossible tasks (e.g. Haber et al., 2021; Leonard et al., 2021). For this study, we defined persistence as children's

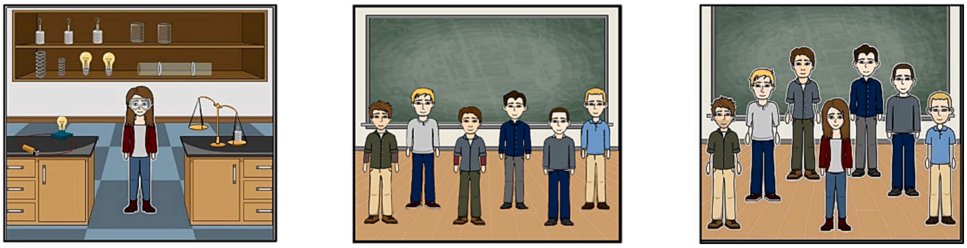

Fig. 1. Example of the female/all-male condition.

willingness to continue playing a science game even after failing on the first trial of the game. Thus, after being introduced to these characters, children were told that it was their “turn to do science.” Experimenters introduced children to a game where they make “a prediction, or thoughtful guess, about whether an object sinks or floats in water.” The game, which was created using Scratch software and based on an app called “Sink or Float” (used by Rhodes et al., 2019), invited children to hypothesize about whether everyday objects (e.g., a banana or a pencil) would sink or float when dropped in water. On the first trial, every child saw the same novel object (a pink circle) and were asked whether they thought the object would sink or float in water. Unlike the app, regardless of response, the first trial was rigged such that all children were marked as “incorrect” on their first trial. The experimenter also gave verbal feedback indicating that the child had responded incorrectly. Children were then invited to keep playing the game or to do something else.

After the first trial, the game was fair (i.e., children's responses were marked as correct or incorrect based on whether objects would actually sink or float in water) and the objects were chosen to be familiar to the children (e.g., an apple, a coin). After each trial response, the child saw either a check or an “X” and heard either a ding or gong sound, depending on whether their response was correct or incorrect, respectively (see Fig. 2). The experimenter also provided verbal feedback after each trial, e.g., “You were right, it did float.” We measured the number of trials children chose to continue playing the game. When children chose to stop playing, they were asked to explain their reasoning.

2.2.3. *Trait attribution question*

Next, children received a forced-choice question to explore children's beliefs about the traits they associated with the individual scientist. They were presented with the target scientist and asked to say whether they were “smart” or “hardworking.” Although we had verbally described the target scientist as both smart and hardworking, we asked this trait attribution question to determine whether children had formulated a distinctive view on the target scientists' ability and effort.

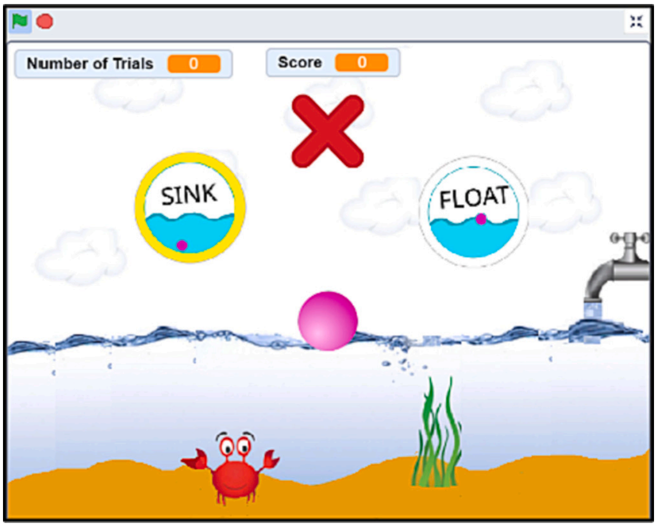

Fig. 2. Example of the first trial on the sink or float task.

2.2.4. *Trait attribution justification*

Finally, children were asked to justify their response to the trait attribution (e.g., “Why do you think the character is smart/hardworking?”). Children's responses were coded using a coding scheme that was developed primarily using a data driven, inductive approach to cover themes that seemed to emerge from the justifications. The categories included references to *effort*, *natural ability*, *the character's occupation*, the *character's physical attributes*, *the character's personality traits, the character's gender,* and *the character's motivation (either intrinsic or extrinsic*; see Table 1 for examples). The coding scheme also included an *uninformative* code (e.g., “I don't know”) which was mutually exclusive (i.e. if the justification was uninformative, the response received no other code; see Table 1). We established interrater reliability by having two researchers independently code 10 % of the data. Overall, agreement was high for the coding scheme (94 % agreement, Cohen's κ = 0.73). Discrepancies were resolved through discussion.

2.2.5. *Memory checks*

Children were asked three sets of memory checks to ensure that they understood that the characters they were viewing were all scientists. The first two sets memory checks occurred during the Introductory Phase and the third occurred before being asked the trait attribution question. During each check, children were asked first about the individual scientist (“Remember this character? What is the character's job?”) and then about the group of scientists (“Remember these characters? What are their jobs?”). To be included in the final analysis, children needed to pass the final memory check by responding that the characters were scientists.

3. Results

3.1. *Persistence task*

Following Rhodes et al. (2019), we used survival analysis to estimate the probability of children choosing to stop the game after a certain

Table 1
Coding scheme and examples.

Code	Example	Mutually exclusive?
Uninformative	“I don't know.”	Yes
Effort	“He works hard.”	No
Ability	“She is smart.”	No
Occupation	“She is a scientist.”	No
Physical attributes	“He has brown hair.”	No
Personality traits	“He seems kind.”	No
Gender	“She's a girl.”	No
Intrinsic motivation	“She wants to do science.”	No
Extrinsic motivation	“She has to be ready when people ask her questions”	

number of trials. Survival analyses are useful in predicting the likelihood of an event occurring. In this case, the event is the child choosing to terminate the game. Two children's trial outcomes were censored (excluded) from the analysis because they persisted playing the game past the final trial of the game (trial 52). We utilized Cox proportional hazards analyses in SPSS, testing for whether condition, gender, age (in months), and task accuracy predicted children's persistence on the science task. Task accuracy was calculated by dividing the number of trials the child answered correctly by the total number of trials the child persisted. We report regression coefficients and standard errors from these models, along with associated p-values.

We first examined children's persistence by condition, using the All-Male group as the reference group. Holding gender, age, and accuracy constant, we found no differences in children's persistence by condition ($\beta = -0.42$, $SE = 0.27$, $p = 0.11$; $\beta = -0.05$, $SE = 0.26$, $p = 0.85$, $\beta = -0.08$, $SE = 0.25$, $p = 0.76$; see Fig. 3). Children dropped out of the persistence task at similar rates (hazard ratios of 0.7, 0.9, and 1 compared to the reference group) across those three conditions.

We also explored the effects of child gender on children's persistence. Boys persisted longer than girls, holding condition, task accuracy, and age constant ($\beta = -0.54$, $SE = 0.20$, $p = 0.005$; see Fig. 4). Additionally, there was an effect of age on persistence ($\beta = 0.05$, $SE = 0.01$, $p < 0.001$). Notably, children's accuracy on the science task did not predict their persistence ($\beta = -0.30$, $SE = 0.41$, $p = 0.47$).

3.2. Trait attribution question

To analyze the trait attribution question, we first used chi-square tests for goodness of fit. We examined the proportion of children who responded that the individual was "smart" versus "hardworking" for each condition. In the All-Male and All-Female conditions, significantly more participants responded that the individual scientist was hardworking rather than smart ($X^2(2, N = 43) = 5, p < 0.05$; $X^2(1, N = 41) = 6.4$, $p = 0.01$). By contrast, significantly more participants in the Female/All-Male condition responded that the scientist was smart rather than hardworking ($X^2(2, N = 45) = 11.75$, $p < 0.001$). In the Male/All-Female condition, participants were equally as likely to respond that the scientist was hardworking as they were to respond that he or she was smart ($X^2(1, N = 37) = 0.03$, $p = 0.87$); see Fig. 5).

Next, we conducted a binomial logistic regression to examine whether child gender or condition were related to children's trait attributions. Children's responses did not differ by child gender ($\beta = 0.03$, $SE = 0.35$, $p = 0.94$). Further results indicated that children who saw same-gender scientists (All-Male or All-Female) judged those scientists as hardworking rather than smart, whereas significantly more children who saw the lone female scientist within an all-male group believed that she was smart rather than hardworking ($\beta = 1.98$, $SE = 0.49$, $p < 0.0001$; $\beta = 1.75$, $SE = 0.47$, $p < 0.0001$). Furthermore, analyses indicated that whereas children in the Female/All-Male group judged her as hardworking, children in the Male/All-Female group were equally as likely to judge him smart as to judge him hardworking ($\beta = -1.07$, $SE = 0.48$, $p = 0.03$). Indeed, 51 % of children in the sample judged the lone male scientist as smart and 49 % children judged him as hardworking. A binomial logistic regression showed that this equal proportion of judgments also differed significantly from children's responses in the All-Female condition ($\beta = 0.90$, $SE = 0.48$, $p = 0.06$). Children's responses in the Male/All-Female condition were not significantly different from their responses in the All-Male condition ($\beta = 0.678$, $SE = 0.46$, $p = 0.14$; see Fig. 5).

3.3. Trait attribution justifications

After judging the individual character as smart or hardworking, we asked children to justify their response (e.g., "Why did you think the character was smart/hardworking?"). We then coded children's responses to the justification question using eight categories that were not mutually exclusive (Table 1). There was a total of 160 responses (6 children did not provide a response and were not included in this analysis).

Overall, 23 % ($N = 37$) of responses were uninformative (e.g., "I don't know"), resulting in 77 % of responses that were informative ($N = 123$). Because responses were not mutually exclusive, there were 130

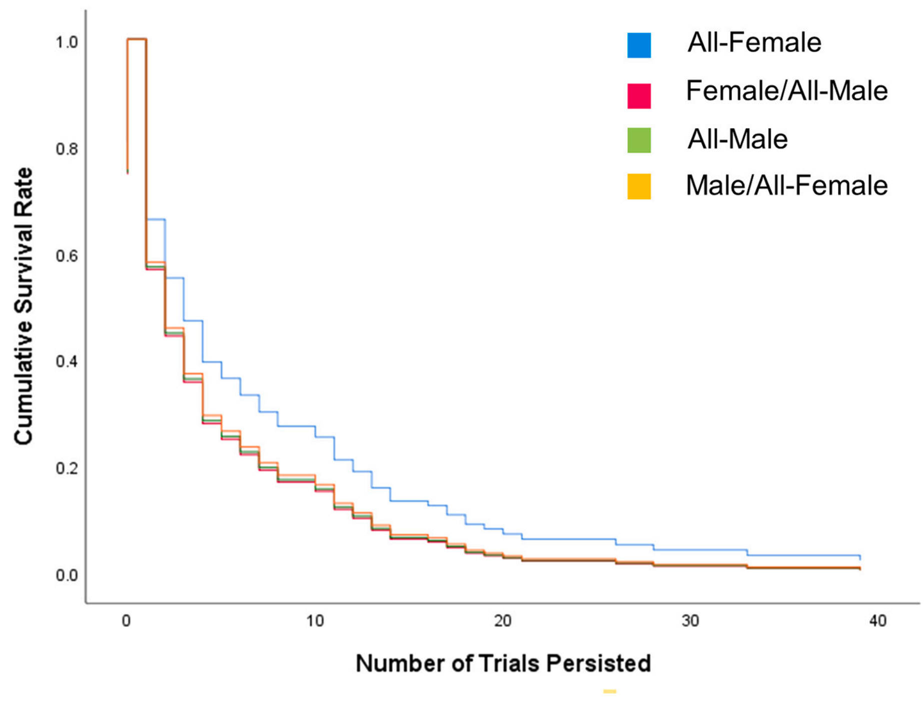

Fig. 3. Survival plot of persistence by condition.

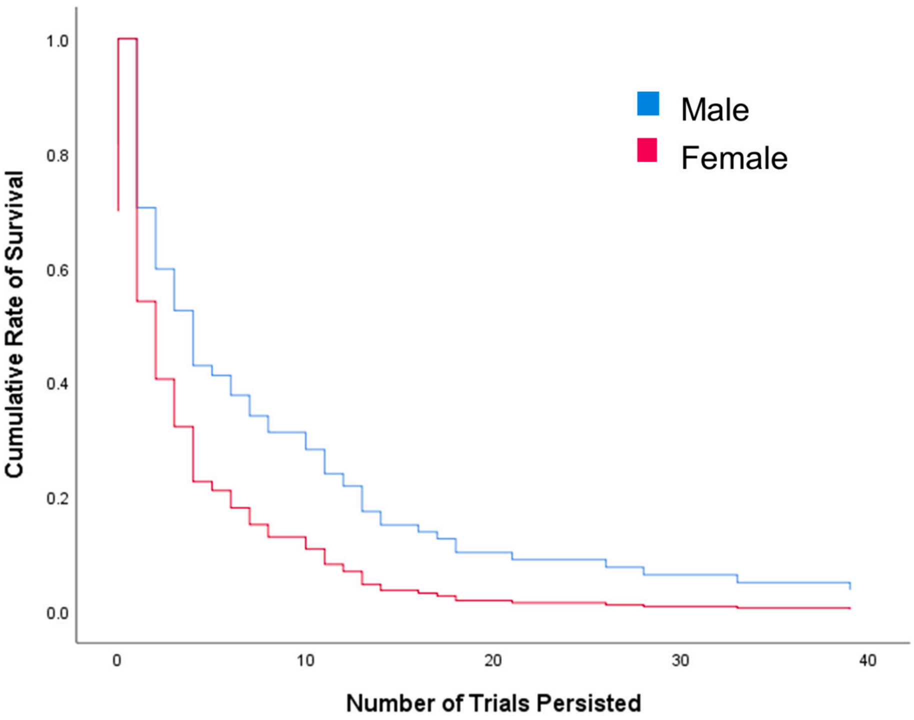

Fig. 4. Survival plot of persistence by gender.

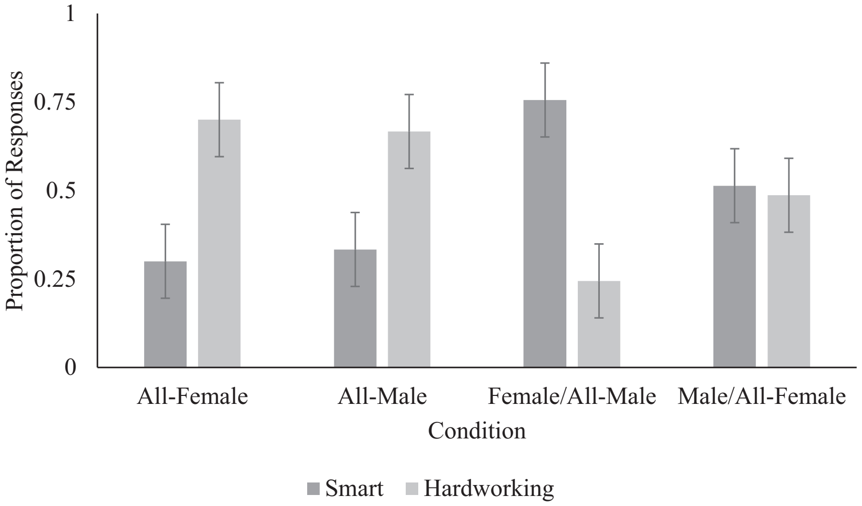

Fig. 5. Proportion of children's trait attributions across the four conditions with standard error bars.

total codes that emerged from the informative responses. Of informative responses, children referenced the individual character's physical attributes, personality, intrinsic motivation, and extrinsic motivation fewer than 5 % of the time respectively. Children referenced the character's gender 0 % of the time. Because these types of justifications occurred so infrequently, we did not explore them further. We found that 35 % of children's justifications included mention of effort (e.g., “He works hard”); 27 % of justifications mentioned natural ability (e.g., “She's smart”); and 44 % of justifications referenced the individual scientist's occupation (e.g., “Because he's a scientist”).

We first explored potential variability in the percentage of children's justifications mentioning effort, natural ability, and occupation depending on whether the child had judged the character as smart or hardworking. Of the children who judged the character as smart, 17 % referenced effort, 48 % referenced natural ability, and 45 % referenced the character's occupation. By contrast, of the children who judged the character as hardworking, 52 % mentioned effort, 6 % mentioned natural ability, and 43 % mentioned the character's occupation (see Table 2). A chi-squared test of independence was performed to examine the relation between the trait judgment (either smart or hardworking) and children's justifications referencing effort, ability, and occupation. The results from this test were significant: children who responded that the scientist was smart were more likely to reference ability and less

Table 2
Codes mentioning effort, ability, and occupation by child's trait attribution judgment (smart or hardworking).

	Reference Effort	Reference Ability	Reference Occupation
Smart	17 %	48 %	45 %
Hardworking	52 %	6 %	43 %

likely to reference effort than children who responded that the scientist was hardworking ($X^2(2, N = 130) = 31.22, p < 0.01$).

We further explored whether there was variability in the percentage of children's justifications mentioning effort, natural ability, and occupation depending on assigned condition (see Table 3). Of those in the All-Female condition, 48 % of justifications referenced effort, 15 % referenced ability, and 33 % referenced occupation. Of those in the All-Male condition, 41 % of justifications referenced effort, 31 % referenced ability, and 38 % referenced occupation. Of those in the Female/All-Male condition, 37 % of justifications referenced effort, 40 % referenced ability, and 43 % referenced occupation. Of those in the Male/All-Female condition, 16 % of justifications referenced effort, 19 % referenced ability, and 59 % referenced occupation (see Table 3). A chi-squared test of independence was performed to examine the relation between condition and children's justifications referencing effort, ability, and occupation. There was no significant difference in children's justifications mentioning effort, natural ability, and occupation between the four conditions ($X^2(6, N = 130) = 11.92, p = 0.06$).

4. Discussion

Taken together, this study provides insight into how visual information about a group's gender composition influences children's judgments and persistence in STEM. Although children's persistence on a STEM task did not differ based on the visual cues they saw, their explicit judgment of whether an individual scientist was smart or hardworking did change based on condition. We found that when children viewed a homogeneous gender group of scientists, they were more likely to judge a highlighted individual as hardworking rather than smart, whereas when they saw a woman among a group of male scientists, they judged her as smart rather than hardworking. Interestingly, children judged a male scientist among an all-female group of scientists differently from a female scientist among a group of males: in that case, they were as likely to judge a man among a group of female scientists as smart as they were to judge him as hardworking. We also asked children to justify their responses to the trait attribution question. We found that children who judged the scientist as smart were more likely to mention ability in their justifications than children who judged the scientist as hardworking. By contrast, children who judged the scientist as hardworking were more likely to mention effort in their justifications. This pattern of responses suggests that children understood the difference between being smart and being hardworking and used that understanding to justify their trait attributions.

4.1. Why did children's trait attribution judgments vary by condition?

The fact that children's response patterns differed by condition indicates that the gender composition of the group of scientists was meaningful information when they were asked to make trait attributions. Within the framework of attribution theory, children's trait attribution judgments provide evidence of their causal ascriptions for the individual scientists' success given the group context (Graham, 2020). Further, the justification response provides a more in depth understanding and illustration of what led children to infer that the scientist was either smart or hardworking. It is possible that children's justifications may have been simple repetition of their response to the trait attribution question (i.e., children who responded "smart" to the trait attribution question may have used a circular justification, "because he/she is smart," when asked why) rather than adding to our understanding of children's thought process. However, the relation between the forced choice question and children's justifications were not one to one (i.e., not every child who said the scientist was smart then justified their answer by saying "because he/she is smart"). For this reason, we believe that children's justifications provide meaningful evidence of their thought process. Additionally, it is important to keep in mind that we did not find statistically significant differences between the groups' trait attribution justifications. Therefore, the interpretations of condition differences that we put forth here should be followed up on through future research.

Table 3
Codes mentioning effort, ability, and occupation by condition.

	Reference effort	Reference ability	Reference occupation
All-female	48 %	15 %	33 %
All-male	41 %	31 %	38 %
Female/all-male	37 %	40 %	43 %
Male/all-female	16 %	19 %	59 %

These data suggest that the experience of viewing a group of same-gender scientists led children to attribute the individual scientist's success to effort more than to ability. One possibility is that when all members of a group are the same gender, children infer that they may all have similar levels of ability, and that effort is the primary factor leading to success. The justification question provides evidence of that possibility in both conditions. Overall, we found that over 40 % of responses mentioned the scientist's effort when justifying their responses. Whereas only 15 % of justifications referenced ability for the All-Female condition, 31 % of justifications referenced ability for the All-Male condition. This discrepancy suggests the possibility that although children were more likely to view the individual scientist in each group as hardworking, there may have also been a slight gender bias toward justifying the individual male scientist's success to ability.

In contrast to the finding that the female scientist in the All-Female group was hardworking, the finding that children judged the female scientist in the Female/All-Male group as smart suggests that the observation of a female scientist situated within an all-male group of scientists led children to attribute the female scientist's success to ability rather than effort. Two explanations seem plausible. First, the fact that children perceived the female scientist as smart rather than hardworking could suggest that children may view women in male-dominated spaces, where natural intelligence rather than effort is often emphasized, as innately brilliant rather than hardworking. This explanation would give credence to the idea that young children were highly attuned to the gender composition of the groups of scientists and potentially to larger gender stereotypes related to STEM (e.g., Leslie et al., 2015; Master, 2021). It is worth noting that children's justifications in this condition mentioned the individual scientist's effort and smartness at about equal percentages (Table 2). Second, children might explicitly evaluate the lone female as smart by considering statistical probability. Thus, if there is a standout individual within an otherwise homogeneous group, then that individual must be exceptionally brilliant, regardless of gender. Prior research indicates that infants are "intuitive statisticians" who are able to track probabilities and show surprise when unlikely outcomes occur (e.g., Xu & Garcia, 2008). Related work with three- and four-year-old children has shown that children make inferences about other people's preferences using probabilistic reasoning (Kushnir et al., 2010). Thus, one could imagine that children in this study might have used probabilistic reasoning when reasoning about what factors had led to a scientist's success within a group that was either similar to them (same gender) or not (different gender).

The Male/All-Female allows us to further explore these possible explanations. Rather than evaluating the scientist as more hardworking or more smart, children in the Male/All-Female condition were equally likely to judge him as smart as they were to judge him as hardworking. This pattern of results differed from children's judgments in the Female/All-Male condition and their judgments in the All-Female condition, but not from their judgments in the All-Male condition. The fact that children perform differently in the Male/All-Female condition than in the Female/All-Male condition suggests that children do take the gender composition of the group into consideration when making judgments and inferences about an individual's character. Indeed, children in the Male/All-Female group responded similarly to children in the All-Male group, but not to children in the All-Female group, suggesting that they are accounting for the fact that the individual scientist is male and using that information to make their trait attribution judgment. However, it is worth noting that although there was not a difference in response pattern when comparing conditions, children's pattern of response within the All-Male group (that the scientist was hardworking rather than smart) did differ from their pattern of response within the Male/All-Female group (that the scientist was equally like to be hardworking and smart). The difference suggests the possibility that children are also using statistical inference to draw conclusions about whether the lone scientist is smart or hardworking (see Kushnir et al., 2010). Further work on children's perceptions of groups of scientists that differ by gender composition should continue to work to disentangle these possibilities.

A comparison of children's justifications in the Male/All-Female condition may shed some light on why there were differences between children's trait judgments in this condition compared to the other three conditions. In this condition, justifications referenced effort 16 % of the time and ability 19 % of the time, whereas in the Female/All-Male condition, justifications referenced effort 37 % of the time and ability 40 % of the time (see Table 3). However, in this condition, justifications had the highest percentage of references to the scientist's occupation than in any other condition (59 % compared to 33 %, 38 %, and 43 %, see Table 3). It appears that regardless of what trait children in the Male/All-Female condition attributed to the individual male scientist, they were likely to explain that the male scientist had this trait because he was a scientist. Thus, for this condition, it seems possible that children might have been more likely to conflate the individual's traits with the group "scientist."

This pattern of results may seem somewhat surprising due to research suggesting that one reason for the lack of women and non-White individuals in STEM is that White men dominate STEM fields and are stereotyped as being brilliant (Chestnut et al., 2018). However, some research has considered how the group "scientists" is conflated with the group "White males" (Chestnut et al., 2018; Jaxon et al., 2019; Rhodes et al., 2019). Thus, children's preconceived ideas of scientists, beyond the differing group contexts presented in this experimental study, are also at play in children's responses here. One area of future research could explore children's mindsets and their perceptions of others' mindsets (e.g., Dweck, 2008). For example, children who view scientists as naturally brilliant might have a fixed mindset whereas children who view scientists as effortful might have a growth mindset. Attribution theory also has space for affective responses to different outcomes (Graham, 2020; Weiner, 1985). Although this research typically considers whether the outcome was good (leading to a happy affect) or bad (leading to a sad or angry affect), one could also imagine that when considering other people's successes and failures, surprise could lead to differing causal ascriptions of success and failures. For example, children may have been surprised to see that a male scientist was the only male among a larger group of female scientists, given their early understanding of STEM stereotypes (Master, 2021). Some work has explored the role of surprise within the attribution process (e.g., Steinsmeister-Pelster et al., 1995). This consideration of affect is outside the scope of this paper, but future work should consider how young children's affect impacts their perceptions and motivations in STEM.

4.2. Why did children's trait judgments, but not their persistence, change based on condition?

One possible mechanism for these findings builds on Rhodes et al. (2019)'s theory about identity-based versus action-based language influencing children's performance on a STEM task, which we mentioned earlier in the paper. Rhodes et al. (2019) posit that identity-based language such as "We are being scientists today" causes children to reflect on whether they could plausibly be part of the group "scientists" or not and leads some children (especially girls) to decide they could not. It seems possible that children respond to visual cues through a similar conceptual pathway. However, in this case, children may not have reflected on the plausibility of *themselves* being part of a group, but on the plausibility of *another person* being part of the group. The fact that this reflection is about another person, rather than about oneself, is one possible explanation for why children's persistence on the STEM task was not impacted by condition.

Additionally, the combination of these findings—that children's trait attributions but not persistence depended on condition–suggests that the stimuli were not powerful enough to induce behavioral differences by condition. Although we intentionally mirrored the brevity of studies that showed an impact of linguistic cues on persistence (e.g., Rhodes et al., 2019) by introducing children to the groups of scientists very briefly, it is possible that exposure to these cues was too brief for their behavior to be impacted. Future research should expose children to the visual cues for longer or multiple times to explore the relative dosage level needed to find condition-level differences in both persistence behavior and in subsequent trait evaluations.

Our analyses also showed age- and gender-related differences in children's persistence on the STEM task but not on their trait attribution judgments. On average, older children were more likely to persist for more trials than younger children. Additionally, boys persisted longer than girls, suggesting that the experience of immediately receiving negative feedback based on the initial incorrect trial was less likely to deter boys than girls from continuing playing the science game (see Dweck et al., 1978). Drawing on attribution theory, perhaps girls, upon failing at the first trial, ascribed this failure to a lack of ability, whereas boys may have ascribed this failure to bad luck or something outside of their control. Additionally, the negative feedback girls received may have activated a feeling of not belonging or unrelatedness to the science game that boys did not experience. Future research should explore how a more encouraging type of verbal feedback or a less harsh type of negative feedback may cushion feelings of not belonging or low ability in girls, leading to greater persistence on the science game across conditions.

4.3. Limitations & future directions

There are several limitations to this research. First, as in much work on gender in STEM, in this paper we address gender as a binary construct despite the fact that gender is not a binary construct. Research indicates that as our society becomes more accepting and aware of the existence of multiple gender identities, there have been increasing numbers of transgender children (Olson et al., 2016). There is currently little work, for example, on how transgender and nonbinary children might respond to STEM gender stereotypes or on how children might perceive transgender scientists. Another limitation is that participants in this study are self-selecting. Thus, it is possible that parents who allowed their children to participate are already interested in science; children who come from families that did not allow their children to participate might have a different base understanding of science and scientists and thus might respond differently to this study. Additionally, we were unable to collect demographic information such as race, ethnicity, and family income about the children participating in this study. Future work should consider the possibility that White and non-White children or children from families with higher incomes and children from families with lower incomes might respond differently to the stimuli presented. For example, a non-White child might perceive a White scientist differently from a White child.

These results expand on prior research that young children are attuned to subtle cues in their social worlds, including visual cues about groups of people. Further, they open questions about how visualizing similar and diverse groups influences children's perceptions of group members and how children's previously held stereotypes impact their judgments of others. Another limitation of this study is that the stimuli portray white characters across conditions, meaning that the judgments that children are making about male and female characters may not apply to Black or non-White characters. Most work in this area has focused on girls in STEM without exploring potential effects of intersectional identity, although recent work in cognitive development has shifted to explore how children use information about intersectional identities (e.g., being Black and female) to make social inferences (e.g., Lei et al., 2020; Jaxon et al., 2019; Shu, 2020; see Crenshaw, 1990 regarding intersectionality). It is well documented that even young children have racial preferences and biases for people in their racial ingroups. (e.g., Dunham et al., 2016; Kinzler et al., 2007). Thus, future work should explore how viewing a racially diverse (or homogeneous) group impacts children's evaluation of scientists as well as how children's racial preferences and biases impact those evaluations.

4.4. Implications across the lifespan

To return to one of the central themes of this paper, women remain underrepresented in STEM fields (National Science Foundation & National Center for Science and Engineering Statistics, 2021). At this time in the United States there is a national effort aimed at increasing the participation of people from underrepresented groups in STEM with the ultimate goal of increasing the STEM workforce (e.g., Building Blocks of STEM Act; National Science Foundation & National Center for Science and Engineering Statistics, 2021). Researchers and policymakers alike are beginning to recognize that the roots of the gender disparity in STEM begin in early childhood. The body of research on adults', teens', and older children's STEM gender stereotypes is important (e.g., Bagès et al., 2016; Bagès & Martinot, 2011; Cheryan et al., 2009; Spencer et al., 1999). But increasingly, early childhood is being recognized as a critical moment for intervening and fostering a lifelong interest in and engagement with STEM. Indeed, a growing body of research has suggested that adults have the power to shape their conversations and interactions with children in ways that will encourage their interest in STEM (e.g., Bian et al., 2017; Lei et al., 2019; Rhodes et al., 2019).

This paper aims to add to this growing body of research by exploring how children's STEM interest, perceptions, and persistence intersect with their ability to visualize groups of scientists that vary by gender composition. More work, especially longitudinal research examining how these early perceptions of STEM impact children's STEM motivation across the lifespan, is needed for researchers to gain a comprehensive understanding of why girls turn away from STEM and how to encourage participation in STEM.

Funding

The work was supported by the National Science Foundation Graduate Research Fellowship #DGE-1840990 awarded to SCK.

Declarations of competing interest

No conflict of interest to declare.

Ethics approval statement

The studies involving human participants were reviewed and approved by the Boston University Institutional Review Board Charles River Campus. Written informed consent to participate in this study was provided by the participants; legal guardian.

Data availability

Data will be made available on request.

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