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SHORT REPORT

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Children lose confidence in their potential to "be scientists," but not in their capacity to "do science"

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Abstract

Over the course of middle childhood, children's interest and beliefs about their own capacities for success in science often decline. This pernicious decline is especially evident among underrepresented groups, including girls, members of some racial and ethnic minorities, and children from lower socioeconomic backgrounds. The present research (N = 306, ages 6–11) found that while children lose interest and feelings of efficacy about their potential to "be scientists" across middle childhood, they maintain more robust interest and efficacy about "doing science." These patterns were confirmed in both longitudinal and cross-sectional analyses; effects were stable or increased across time and age. Mediation analyses revealed that the positive effect of action framing is partially accounted for by children's views that the group of people who do science is more inclusive than the category of scientists. These findings suggest that using action-focused language to encourage children in science is more inclusive and may lead to more science engagement across middle childhood than language that emphasizes *scientists* as an identity category. Implications for educational practices will be discussed.

KEYWORDS
identity, language, longitudinal, motivation, science, self-efficacy

There is a pressing need to expand and diversify the workforce in science and technology. The underrepresentation of women and racial/ethnic minority groups constrains scientific innovation (Bell, Jaravel, Petkova, & Reena, 2017) and has economic ramifications for both underrepresented groups and the economy as a whole (Ferrant & Kolev, 2016; Ferrant & Nowacka, 2015). Although numerous factors conjointly shape educational and occupational outcomes, these endpoints are constrained by developmental pathways that begin in early childhood (Eccles, Wigfield, Harold, & Blumenfeld, 1993). For instance, variation in children's interest and feelings of competency in particular subjects is fairly stable from early elementary school through adulthood (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Together with stereotypes about who usually succeeds in particular fields, children's interest and efficacy beliefs are stronger predictors than early variation in ability of ultimate educational and occupational outcomes (Muenks, Wigfield, & Eccles, 2018). Thus, examining how children develop interest and competency beliefs about science across childhood—and particularly how we might intervene to bolster these beliefs—is critical to national and international efforts to expand the workforce in science and address the persistent problems of gender, racial, ethnic, and economic disparities in access to these relatively high-status occupations.

As in many academic domains, children's interest and feelings of efficacy in science often decline across childhood (Jacobs et al., 2002). For science in particular, this decline becomes more precipitous in middle childhood and is particularly pronounced among girls and members of racial, ethnic, and economic groups that are typically underrepresented in science professions (Wigfield, Eccles, Simpkins, Roeser, & Schiefele, 2015). One reason why some children lose interest and confidence in science in middle childhood is because they begin to view the possibility of "being a scientist" as incompatible with their identities (Andre, Whigham, Hendrickson, &

Chambers, 1999; Cheryan, Master, & Meltzoff, 2015). Experimental and qualitative research has revealed numerous, pervasive cultural stereotypes about scientists. Some of these stereotypes entail particular social identities—for example, that scientists are male, White, and of relatively high socioeconomic status (Archer et al., 2012, 2013; Barman, 1999; Buldu, 2006; Chambers, 1983; Finson, 2002; Fort & Varney, 1989; Wong, 2015). Other stereotypes entail individual characteristics, including beliefs that scientists possess innate brilliance, are solitary and introverted, or generally have some kind of "special science brain" (Archer et al., 2012, 2013; Leslie, Cimpian, Meyer, & Freeland, 2015). These various stereotypes also interact with one another—as when children (Bian, Leslie, & Cimpian, 2017) and adults (Leslie et al., 2015; Meyer, Cimpian, & Leslie, 2015; Storage, Horne, Cimpian, & Leslie, 2016) expect those who are brilliant to also be White and male. Together, these beliefs can make it difficult for children who do not see themselves matching these stereotyped notions of scientists to imagine themselves succeeding in science (Master, Cheryan, & Meltzoff, 2017; Miller, Nolla, Eagly, & Uttal, 2018), thus leading to decreased interest and confidence in their own capacity for success.

There are a number of ways to combat these processes, including exposing children to diverse role models in science (Dennehy & Dasgupta, 2017; Stout, Dasgupta, Hunsinger, & McManus, 2011) and helping children to actively integrate science behaviors into their own personal and group identities (Master, Cheryan, & Meltzoff, 2016; Master et al., 2017; Master & Meltzoff, 2016). Here, we begin to explore a complementary approach, one designed to reduce the extent to which these identity-based questions influence the processes by which children form their beliefs and attitudes about science in the first place. In particular, we test whether children have higher self-efficacy and more interest in science when they think of science as *actions that people do* instead of as defining an identity category to which people need to belong.

We considered that fairly subtle linguistic cues could shape whether children bring to mind representations of science as action or as indicative of identity. Children often interpret *category labels* and *generic descriptions* as signaling that a referenced category is fundamental to identity, stable over time, and marks a distinct kind of person (Gelman & Heyman, 1999; Gelman, Taylor, & Nguyen, 2004; Gelman, Ware, & Kleinberg, 2010; Rhodes, Leslie, Bianchi, & Chalik, 2017; Rhodes, Leslie, & Tworek, 2012; Rhodes & Mandalaywala, 2017; Segall, Birnbaum, Deeb, & Diesendruck, 2015; Waxman, 2010). In the case of science, then, children are likely to interpret the use of *category labels* (e.g. "Come be a scientist!") and *generic descriptions* (e.g. "Scientists discover new things about the world")—which are frequently used in conversations about science with children (Rhodes & Bushara, 2015; Rhodes & Leslie, 2017)—as meaning that *scientists* are a distinct kind of person, and that only some people inherently have the potential to become scientists. Children draw these inferences following even relatively brief exposures to labels and generic descriptions (Gelman et al., 2010; Rhodes et al., 2012).

Research Highlights

- Children show more interest in and feel more efficacious about "doing science" than "being a scientist" across middle childhood.
- Children's interest and self-efficacy in doing science were protected from age-related declines in their interest and efficacy about being a scientist, both longitudinally and cross-sectionally.
- The positive effects of action framing occurred partly because children had more inclusive views of who can do science than who can be a scientist.

The use of identity-focused language may also lead children to view science in a manner that can support the acquisition of other problematic stereotypes and beliefs (Bastian & Haslam, 2006; Pauker, Ambady, & Apfelbaum, 2010; Rhodes, Leslie, Saunders, Dunham, & Cimpian, 2017). For instance, the view that only a certain kind of person can be a scientist is compatible with the notion that such a person is likely White and male—at least in the United States (e.g. Miller, Eagly, & Linn, 2015). In contrast, describing science as *action* (e.g. "Let's do science! Doing science means discovering new things about the world!") can communicate much of the same information, but is less likely to be interpreted by children as meaning that science is identity-defining and thus is less conducive to the development of other maladaptive beliefs (Foster-Hanson, Cimpian, Leshin, & Rhodes, 2018; Gelman & Heyman, 1999).

In the present research, we varied the language that we used to ask children aged 6–11 about science, to test whether children have more positive beliefs about their capacities to *do science* than to *be scientists*. We focus on middle childhood because of well-documented average declines in science interest and self-efficacy that often occur across this developmental period. We hypothesized that describing science as action would activate representations of science that sidestep potentially problematic representations invoked by identity-focused language. Specifically, we tested whether describing science as action (e.g. "Let's do science!") would prevent children from questioning whether they have the relevant identity qualities to be a scientist and would therefore lead to more inclusive representations and increased science efficacy. If so, then encouraging children in science by discussing science as action instead of in terms of identities—although a subtle shift—could lead children to approach science with more positive beliefs and attitudes and result in different trajectories in the pipeline to more advanced opportunities in STEM. We test this hypothesis both longitudinally and cross-sectionally for convergent evidence. Finally, we asked whether these effects extend broadly by including a racially, ethnically, and economically diverse sample of children from public schools in New York City.

1 | METHOD

1.1 | Participants

Children were recruited from two public elementary schools in New York City. Parents were asked to report their child's racial and ethnic background when they completed the consent form. The samples were similar to the overall population of the schools (as reported by insideschools.org); from one school, the participating sample was 65.6% Hispanic, 14.4% White, 4.4% Black, 3.3% Asian, 8.9% Biracial, and 3.3% other, and the other was 40.2% Hispanic, 23.2% White, 12.2% Black, 11.0% Asian, and 13.4% Biracial. The two schools are economically diverse, with one school primarily low income (68% of students were eligible for free or reduced lunch according to the standards put forth by New York State), and the other with a substantial population of low-income students as well (41% of students).

The sample included in the longitudinal analyses consisted of 212 children (100 male, 111 female, 1 gender unreported); M_{age} Wave 1 = 7.93, M_{age} Wave 2 = 8.18, M_{age} Wave 3 = 8.52) recruited from second- and third-grade classrooms. For this sample, 87.2% children participated in all three waves of data collection (the remainer participated in two). Additionally 30 children began testing but were not included in these analyses for the following reasons: (a) scale training failure in Wave 1, indicating inattention to the task (N = 8); (b) software failure (N = 13); and (c) participation in only one wave (N = 9).

The sample included in the cross-sectional age comparisons were the 200 children from the longitudinal cohort who participated in Wave 2 data collection, as well as 94 fourth and fifth graders (M_{age} = 10.26, SD=0.66; 44 male and 50 female) who were tested at this single point in time. The sample of fourth and fifth graders from one of the schools was: 57.1% Hispanic, 26.8% White, 8.9% Black, 3.6% Asian, 1.8% Biracial, 1.8% other, and the other sample was: 45.5% Hispanic, 31.8% White, 4.6% Black, 9.1% Asian, and 9.1% Biracial.

1.2 | Materials and procedure

Children were randomly assigned to either the identity-focused or action-focused language condition. At Wave 1, for children in the longitudinal study, they first watched a 3-min video that introduced the scientific process using identity- or action-focused language (available at https://osf.io/56fg9/). Depending on condition, the character used either generic, identity-focused language (e.g. "Today, we're going to be scientists! Scientists use their five senses to learn about the world…") or action-focused language (i.e. "Today, we're going to do science. People who do science use their five senses to learn about the world…"). The video was intended to explain the concept of science to children who might not yet know what science entails. The video was also intended to help get children into an action- or identity-focused mind frame, but the condition manipulation did not rely on the video alone—condition-specific language was also incorporated into the study measures and remained consistent at each timepoint. Thus, the goal of the study was not to test for long-term effects of the video, but rather to test whether we see different developmental trajectories for children's beliefs and attitudes about "being scientists" or "doing science." Note that the group of older children never saw the video, as we assumed that older children already had more explicit representations of what science entails—for them, the only condition manipulation was in the wording of the study questions.

1.3 | Dependent measures

These measures were asked at all three waves for children participating in the longitudinal study, unless otherwise noted, and were also asked of the older cohort of children included in the cross-sectional age comparisons. All dependent measures were administered via computer using animations, so that test procedures were standardized across participants and schools. The test questions as they were administered can be viewed at https://osf.io/56fg9/.

1.3.1 | Interest in science

Children were asked (a) Whether or not they would like to "be a scientist" or "do science" (1 = Yes, 0 = No), and (b) How much they want to "be a scientist" or "do science" (1 = really don't want to, 4 = really want to).

1.3.2 | Science self-efficacy

Children were asked to rate how good they thought they would be at "being a scientist" or "doing science" on a 4-point scale (1 = really not good; 4 = really good).

1.3.3 | Science inclusivity beliefs

We also assessed the extent to which children have inclusive representations of science/scientists, as a potential mediator for our dependent variables of interest. We reasoned that the "do science" language might influence children's science interest and self-efficacy because such language leads them to think that more adults in their community do the target behavior, and therefore, that they can do so as well. For this measure, children were asked to think of all the parents of the kids at their school and to judge how many of those parents either "were scientists" or "did science" using a pictorial scale (on which they first received training), ranging from 1 = just one person to 5 = all people. This measure was included in Waves 2 and 3 only.

1.3.4 | Science knowledge measure

To better characterize our sample as high or low performing in science, children's knowledge of science content was assessed at Wave 3 only using second- and third-grade test questions pulled from curricula informed by New York State's Next Generation Science Standards, an initiative to create new research-based education standards in science for children in grades K-12. Children responded to five multiple-choice questions spanning topics such as forces and motion, properties of matter, plate tectonics, and natural selection. The wording of these questions was identical across condition.

1.3.5 | Analytic strategies

All data and analytic code are available at https://osf.io/56fg9/. For the longitudinal analyses, we employed a multilevel model to account for the repeated nature of the design, nesting waves within individual and individuals within school. Both condition and wave were contrast coded, allowing for more precise estimations of random slopes. We conducted separate analyses for the dependent variables using the lme4 package (Bates, Machler, Bolker, & Walker, 2014) in R. All data and code are available on OSF at: https://osf.io/56fg9/. Supplementary analyses found similar patterns across gender and racial and ethnic groups in this sample (all *ps*> 0.10) and thus these variables were not included in the main analyses presented here (see Supplementary Online Materials[SOM]).

To test for mediation, we conducted moderated mediation analyses using the mediation package in R (Tingley, Yamamoto, Keele, & Imai, 2013). The overall moderated mediation model tested whether the influence of language condition on children's science interest and self-efficacy was mediated by inclusivity beliefs about science, and whether this overall mediation pattern was moderated by time (Full results are in Table S1 in the SOM).

For cross-sectional data analyses, we ran regression analyses predicting our dependent variables as a function of condition and age. Age was treated as a continuous predictor and centered in all analyses.

2 | RESULTS

2.1 | Sample characteristics

Confirming that random assignment was successful, the samples in the two language conditions did not differ by age, gender, race, or ethnicity, *ps* > 0.10. To characterize our sample, we examined children's performance on the science standards questions. Overall, the sample performed relatively poorly on this measure (proportion correct, M = 0.54, SD = 0.24). Supplementary analyses confirmed that the language manipulation appeared to affect both higher and lower performing students in a similar way in this sample (see SOM).

2.2 | Longitudinal analyses

For science interest, more children wanted to do science (M = 0.85, SE = 0.24) than be a scientist (M = 0.65, SE = 0.30), β = 1.14, SE = 0.37, z = 3.09, p = 0.002 (as assessed by the binary measure), and children wanted to do science more (M = 3.10, SE= 0.07) than they wanted to be scientists (M = 2.80, SE = 0.07), β = 0.29, SE = 0.10, t = 2.89, p = 0.004 (as assessed by the follow-up scale). Additionally, children were less interested in science over time as reflected in both their binary decisions, β = −0.37, SE = 0.15, z = −2.55, p = 0.011, and their ratings, β = −0.10, SE = 0.04, t = −2.43, p = 0.016. There were no interactions between condition and time, *ps* > 0.50, suggesting consistent effects of language at each point in time, even as interest in science declined more generally (see Figure 1a,b).

For self-efficacy, children thought they would be better at doing science (M = 3.09, SE = 0.07) than being scientists (M = 2.84, SE = 0.06), β = 0.24, SE = 0.09, t = 2.65, p = 0.009, and children thought they would be worse at science over time, β = −0.12, SE = 0.04, t = −3.04, p = 0.003. Further, the effects of language interacted with time, β = 0.21, SE = 0.08, t = 2.66, p = 0.008, such that self-efficacy declined across time for children in the identity-focused condition, but not for children in the action-focused condition (Figure 2).

One possible reason why this subtle linguistic cue has an effect on children's science interest and self-efficacy might be due to the perceived exclusivity of the role—perhaps the "do science" language brings to mind a more inclusive representation that leads

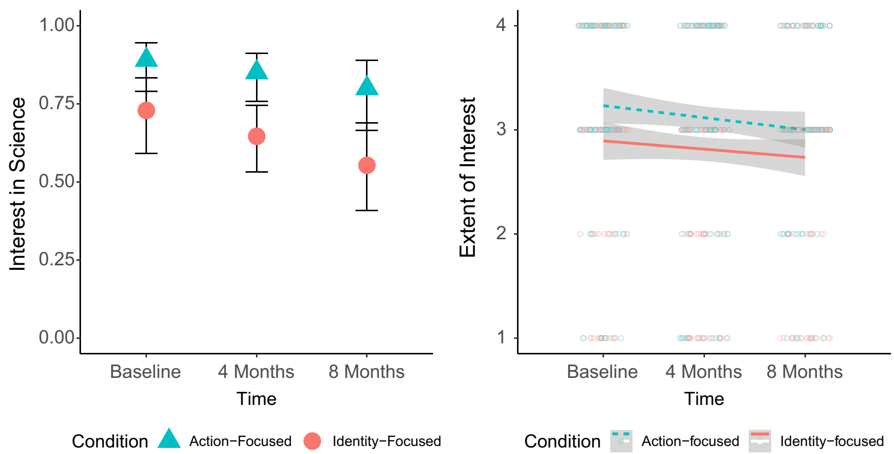

FIGURE 1 The left panel (a) shows the predicted values for children's responses for main effects of condition and time regarding whether they want to "be a scientist" or "do science," with 95% confidence intervals. In the right panel (b), the lines show predicted values for main effects of condition and time on how much children wanted to "be scientists" or "do science." Shaded regions represent ± 1 SE. Small circles reflect the responses of individual children at each point in time and are jittered to make the distribution of responses easier to see

children to think that more adults in their community do the target behavior, and therefore, that they can do so as well. Indeed, children thought that more adults did science (M = 3.41, SE = 0.08) than were scientists (M = 2.66, SE = 0.08), β = 0.61, SE = 0.14, t = 4.45, p < 0.001, and there was suggestive evidence that the extent of this difference increased across time (the interaction between condition and time: β = 0.30, SE = 0.16, t = 1.85, p = 0.066). We also found that the benefit of the action-focused condition on children's science interest (particularly, their binary decision, β = 0.054, 95% CI [.01, 0.10]) and self-efficacy (β = 0.120 [.04, 0.20]) were partially mediated by their increased beliefs that more people in their community do science (for details of these models, see Table S1 in the SOM).

2.3 | Cross-sectional analyses

In addition to comparing children across time, we also compared children participating in the longitudinal study (at Wave 2) to samples of older children drawn from the same schools. In general, these analyses revealed similar patterns of age-related changes as were found for the analyses of the same children across time. For science interest (the binary choice), as in the previous analysis, more children wanted to do science (M = 0.72, SE = 0.19) than be scientists (M = 0.54, SE = 0.17), β = 0.78, SE = 0.26, z = 3.04, p = 0.002, and the proportion of children interested in science declined with age, β = −0.31, SE = 0.15, z = −2.12, p = 0.034 (Figure 3a). For the extent of children's interest, again, children in the action-focused condition (M = 3.06, SE = 0.09) expressed more interest in science than children in the identity-focused condition (M = 2.60, SE = 0.08), β = 0.46, SE = 0.12, t = 3.82, p < 0.001, and interest in science declined marginally with age, β = −0.13, SE = 0.07, t = −1.86, p = 0.064 (Figure 3b).

Also, as in previous analyses, children felt more efficacious about their capacity to do science (M = 3.06, SE = 0.07) than be a scientist (M = 2.77, SE = 0.07), β = 0.30, SE = 0.10, t = 2.90, p = 0.004, and children generally thought they would be worse at science with age, β = −0.13, SE = 0.06, t = 2.18, p = 0.030. Although there was no overall interaction in this analysis (β = 0.11, SE = 0.09, t = 1.30, p = 0.194), we nonetheless examined the slope of the lines associated with age in the identity- and action-focused conditions separately because of the findings of the longitudinal analysis (Figure 2). Indeed, self-efficacy declined with age for children's beliefs about their capacity to be scientists, β=−0.13, SE = 0.07, t = −2.01, p = 0.046, but not in their capacity to do science, β = −0.02, SE = 0.06, t = −0.34 p = 0.74 (Figure 4).

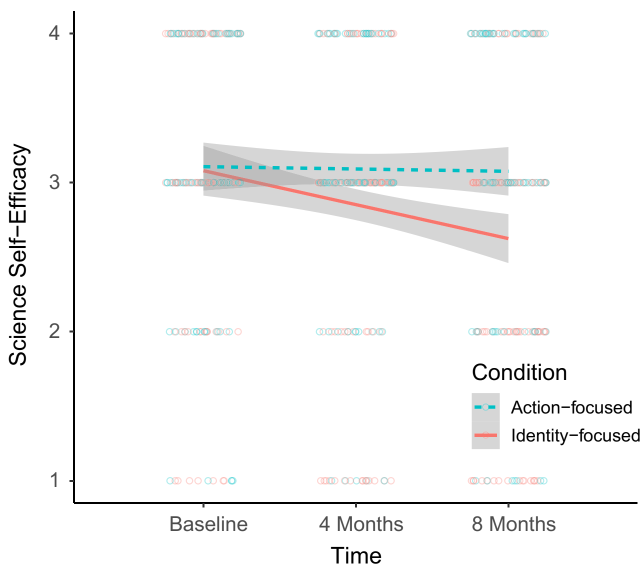

FIGURE 2 The lines show the predicted values for the interaction between time and condition for how good children think they will be at "being scientists" or "doing science" over time, with shaded regions representing ± 1 SE. Small circles reflect the responses of individual children at each point in time and are jittered to make the distribution of responses easier to see

3 | DISCUSSION

The present research found that science interest and self-efficacy show less problematic trajectories across middle childhood when children are asked to think of science as action, instead of as identity-defining. The benefits of action-focused language emerged in both longitudinal and cross-sectional analyses (despite age differences across samples), suggesting the robustness of these effects. Further, the benefit of action-focused language partly occurred because children have more inclusive representations of who they think can "do science" than of who can "be a scientist." That is, one mechanism by which action-focused language seems to benefit children's beliefs and attitudes is by leading them to think that a broader range of people can engage with science.

These negative consequences of identity-focused language are important to consider because these forms of language are highly pervasive in input to young children. In analyses of children's media (Rhodes & Leslie, 2017) as well as of informal science learning environments (Rhodes & Bushara, 2015), category labels and generic descriptions were the most common way of communicating about science. Given the prevalence of identity-focused language, these findings have implications for potential interventions. For instance, having teachers talk about doing science instead of being scientists may result in children approaching new science learning tasks with more efficacy and interest. A promising avenue to explore in future work is the possibility that doing so might initiate a positive recursive cycle, wherein children who hear about doing science are more likely to engage initially and subsequently feel more secure exploring the domain, leading effects to grow over time.

We found beneficial effects of action-focused language that were consistent across gender, racial and ethnic groups, and skill-level in science, suggesting that targeting action-focused language may be a promising approach for fairly broad-scale intervention during middle childhood. In light of previous work that found greater benefits of action-focused language for children from underrepresented groups (2019), it may seem surprising that the

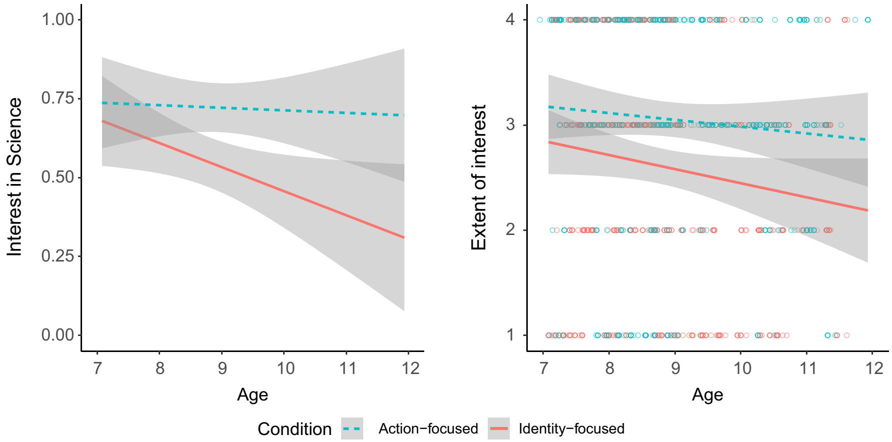

FIGURE 3 The left panel (a) shows the predicted probabilities for children's responses for main effects of condition and time regarding whether they want to "be a scientist" or "do science." The right panel (b) shows the predicted values for main effects of condition and time for how much children want to "be scientists" or "do science." In both graphs, shaded regions represent ± 1 SE. Small circles reflect the responses of individual children at each point in time and are jittered to make the distribution of responses easier to see

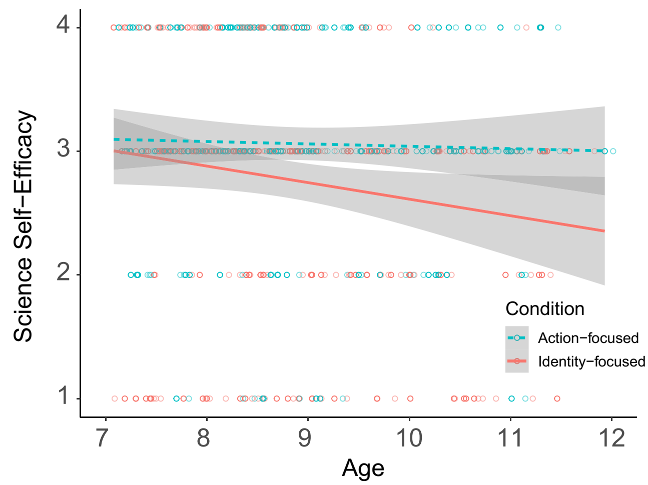

FIGURE 4 The lines show the predicted values for main effects of condition and time for how good children think they will be at "being scientists" or "doing science" over age, with shaded regions representing ± 1 SE. Small circles reflect the responses of individual children at each point in time and are jittered to make the distribution of responses easier to see

language manipulation benefitted children from all backgrounds to a similar degree. This pattern might depend on the specific social context of these schools; both participating schools were racially, ethnically, and socioeconomically diverse and contained relatively high percentages of students from low-income backgrounds (across race and ethnicity). Thus, few children from these schools might see themselves as consistent with stereotypic notions of scientists, which could contribute to the beneficial effects of the action-focused language across groups. It is also possible, however, that we lacked statistical power to detect differences in language effects across demographic groups. Further large-scale research will be necessary to identify whether language-based interventions might be particularly helpful for some populations of students.

3.1 | Limitations and future directions

We found that children have more inclusive representations of who can "do science" than who can "be a scientist," but the features that underlie this greater inclusivity are still unclear. For instance, one possibility is that children have social stereotypes about who can be a scientist (e.g. beliefs that scientist = White and male), but more inclusive ideas about who can *do science*. Another possibility, however, is that children think it requires more skill to be a scientist than to do science. Of course, these possibilities are not mutually exclusive, and even levels of skill are perceived as tied to demographic characteristics; for instance, children are more likely to consider men to be "brilliant" than women (Bian et al., 2017). Yet, use of identity- versus action-focused language is likely to have implications beyond influencing perceptions of difficulty or required skill. For instance, when children are presented with challenging tasks, and experiences of difficulty are experimentally controlled to be identical across language conditions, children still show more persistence after hearing action-focused than identity-focused language (Foster-Hanson et al., 2018; Rhodes, Leslie, Yee & Saunders,2019). Nevertheless, future work should identify more precisely how identity- versus action-focused language influences the inclusivity of children's representations and in particular how language framing interacts with children's baseline perceptions of difficulty for a given domain.

It is also an open question whether the effects of language carried over to subsequent activities. Because we incorporated the target language directly into the test questions (e.g. asking children if they wanted to "do science" or "be a scientist"), we did not test to see if this influences behaviors such as task persistence. In related work, however, Rhodes et al., 2019 found that girls who were asked to "do science" showed more persistence on a subsequent science game than those asked to "be scientists," suggesting carryover from language exposure to subsequent behavior. Future work should examine whether language exposure can lead to effects that extend over greater lengths of time.

An additional consideration is how the initial video might have influenced children's responses. Children saw a video that provided more extensive action-focused or identity-focused language in the first wave of the longitudinal study. Because we saw similar effects across time points (regardless of whether the video was shown), however, and among the sample of older children (who never saw the video), the observed condition differences in interest and efficacy likely stem from the different representations activated by the questions themselves, not from the video exposure.

Finally, we tracked children only over the course of a single academic year. Tracking children over a longer period of time would allow for more powerful tests of the interactive effects of age and language than we were able to perform here. Tracking children over longer timespans would also allow us to examine the effects of language in older children or even college students who have made more concrete decisions about whether or not to engage with science. There may be a critical point at which it is necessary to incorporate science into one's self-concept (Amemiya & Wang, 2018). For example, Oyserman and Destin (2010) suggests that adolescents need to be able to imagine a possible self in order to generate the intermediary steps to arrive at that future goal. If science is not part of an adolescent's identity, then they may not engage with science. Focusing on the act of doing science rather than on the identity, however, might help younger children reach the point where they are engaged and interested enough in science to later integrate it into their identities.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are openly available in OSF at https://osf.io/56fg9/.

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