2023

How perceptual and linguistic cues influence young children’s persistence and interest in STEM

https://hdl.handle.net/2144/46233

BOSTON UNIVERSITY

WHEELOCK COLLEGE OF EDUCATION & HUMAN DEVELOPMENT

Dissertation

HOW PERCEPTUAL AND LINGUISTIC CUES INFLUENCE YOUNG CHILDREN'S PERSISTENCE AND INTEREST IN STEM

by

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B.A., Swarthmore College, 2017

Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
2023

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DEDICATION

This dissertation is dedicated to my Dadi, Dr. Sudha V. Kumar,

and

in loving memory of Francyne Leontios Diedrich, affectionately known as Granny or Fran.

ACKNOWLEDGMENTS

First, I would like to thank Dr. Kathleen Corriveau, my advisor. Kathleen, I cannot thank you enough for giving me the opportunity to be a graduate student in your lab. I still vividly remember interview day at BU Wheelock in 2018. It was my very first grad school interview and I was incredibly nervous, but I remember being thrilled by the way you talked to me like an intellectual equal. It was the first time that I felt like my original research ideas were worth something. And I feel lucky that I have felt the same attitude of respect in all of our interactions since then. Thank you for giving me the space to begin building a program of research that I am proud of and for providing me with support when I need it. Your support throughout this PhD journey truly means the world to me.

Next, I would like to give a very special thank you to Dr. Janine Bempechat, Dr. Eleonora Villegas-Reimers, and Dr. Lin Bian who have all graciously served as members of my dissertation committee. Your support, guidance, and enthusiasm for this research has been exceptional and has given me confidence in the importance of this work even in challenging moments. Janine, thank you for your warmth and kindness as well as your critical insight on many aspects of this dissertation. I especially have enjoyed discussion motivation and mindset with you and considering the applications of this work. Eleonora, thank you also for your kindness and unfailing enthusiasm for this work across many discussions. I believe that your intellectual insights, especially regarding applications of this work, have immeasurably strengthened it. Lin, much of your work is foundational to the work presented in this dissertation and to my research program as a whole; I am honored that you have taken the time and effort to provide feedback on this work over the past year. I believe this dissertation is strengthened thanks to the feedback from each member of this committee. I thank you all for providing invaluable support not only regarding my dissertation, but also regarding my future in academia and my next steps.

I also wanted to take this moment to thank a few other academic mentors who have supported me through this process, typically in the form of a motivational talk. Thank you to Dr. Anna Shusterman; being your lab manager at Wesleyan gave me the opportunity to see how research can be put into practice to directly support communities outside of academia. I am forever grateful for your guidance over the past five years. Thank you to Dr. Stella Christie; doing my undergraduate thesis with you helped me realize that academia was a place where I could learn and grow and a place where I could make a difference for others. Thank you to Dr. Narges Afshordi; my summer internship with you in the Harvard Lab for Developmental Studies was truly a formative experience for me. I have never forgotten that summer, the support you gave me then, and the support you have given me since.

I am so grateful for the many friends, mentors, and family members who have supported me through writing this dissertation and through pursuing my PhD in Applied Human Development. Thank you to my mom, dad, and twin brother, who have all provided a safety net for me in the form of unconditional love and support, non-judgmental listening ears, and an unwavering belief in my ability to succeed. Thank you to my girlfriend, Claudia, for being there for me through all of the ups and downs that come with pursuing a PhD, for believing in the importance of my work, and for making sure that I take time to have fun in addition to working.

I would have been lost without the support of my amazing cohort-mates and friends, Anna Skubel, Christine Marsico, Kate Newman, Mason Blake, and Amanda Haber. Our group chats and in person chats kept me going on many a hard day. I know that I can always keep it real with you all.

I truly cannot imagine doing this degree without my friend, cohort-mate, and lab mate, Amanda Haber. There was a time when we literally spent 12 hours a day, every day of the week together; even during the pandemic, we spoke on the phone or via Zoom every day. I am so proud of all that we have achieved together and individually. I have never felt so free when collaborating with another person—free in the knowledge that if my idea is bad, you'll tell me; if it's good, you'll tell me; and if it needs some work but is on its way there, you'll tell me. All without judgement and all with the goal of strengthening the work. Not only are you an amazing colleague, but you are also an incredible friend and I feel lucky to be part of your life. I know that this is only the beginning of a lifetime of collaboration.

I also want to thank my friend and lab mate, Hannah Puttre, for providing support and entertainment on the daily. It is hard for me to imagine life in the lab without you. Not only have I had the joy of collaborating with you, I have also learned so much from you about how to be direct about my wants and needs in academic spaces. I have especially loved sharing an office and a desk with you!

Finally I would like to thank the members of the Social Learning Lab, past and present. In particular, thank you to Ayșe Payir, Kiki Ghossainy, Sarah Suarez, and Niamh

McLoughlin. I have had the pleasure of collaborating with each of you (especially related to statistics!) and also of getting to know you. Thank you for being such fantastic role models for what to do as I move to a postdoc position. Thank you to Adine DeLeon; it has been so great to get to know you this year! Thank you also to the many research assistants who have worked with me over the past five years. This work would not have been possible without you. In particular, thank you to Sam Barbero, Cerelia Liu, and Mia Holder. You all made immense contributions to the work in this dissertation and it has been a great honor to watch all of you grow through the years.

HOW PERCEPTUAL AND LINGUISTIC CUES INFLUENCE YOUNG CHILDREN'S PERSISTENCE AND INTEREST IN STEM

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ABSTRACT

Across three papers in this dissertation, I investigate how perceptual and linguistic cues impact young children's behavior and perceptions in the domain of STEM. Women and non-White people are underrepresented in STEM fields. One way to understand the early roots of the gender gap in STEM is to consider how the messages that children receive from adults and larger society shapes their understanding of who belongs in STEM and, consequently, who does not. The domain of STEM thus also presents a unique lens through which to study how group membership (or a lack thereof) influences children's decision-making and beliefs in early childhood. In Paper 1, I focus on perceptual cues to belonging, investigating how visualizing groups of scientists that vary by gender impacts four- to six-year-old children's STEM-related persistence and perceptions. In Paper 2, I focus on linguistic cues, examining whether four- to seven-year-old children prefer to learn from scientists described as innately brilliant or as hardworking. In Paper 3, I explore how the language and character diversity in a science storybook impacts five- to seven-year-old children's science interest, feelings of self-efficacy, and persistence in STEM. I conclude by addressing implications of this work for psychology and educational settings and exploring future directions.

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CHAPTER ONE

Introduction

How do children's beliefs about and understanding of their social worlds impact and relate to their motivation, including their interest, feelings of self-efficacy, persistence, and learning preferences? In this dissertation, I investigate the domain of STEM as an area rich for exploring these questions due to the underrepresentation of women and non-White people in STEM fields (NSF, 2023). Globally, the question of how to encourage the participation of underrepresented groups in STEM is of urgent concern as projections indicate that by 2050, 75% of jobs will be STEM-related (World Economic Forum, 2018). Indeed, the United Nations theme of International Women's Day 2023 is "DigitAll: Innovation and technology for gender equality" with a focus on celebrating women and girls in STEM and calling attention to the economic and social consequences of a global lack of gender parity in STEM fields (United Nations, 2023). In the United States, women and non-White people are underrepresented in STEM, with White males continuing to hold the majority of careers in and to obtain degrees in STEM (NSF, 2023). To give one example, in the United States in 2020, 21% of bachelor's degrees earned in computer science were awarded to women and 8.3% were awarded to Black students (NSF, 2023). Accordingly, institutions like the National Science Foundation have made broadening the participation of underrepresented groups like women, non-White people, and disabled people a primary goal.

Pressing questions for educators, policy makers, and researchers have centered on gaining an understanding of how this gender and racial gap develops and how to mitigate it. There are myriad ways to tackle these large questions. Across three papers in this dissertation, I contribute to answering them by exploring the complex developmental origins of the gender and racial gap in STEM. Despite this gap, girls have consistently been shown to outperform boys in science in the U.S. and an assessment of international data shows little difference in boys' and girls' science performance (Stoet & Geary, 2018; Voyer & Voyer, 2014). Popular sources have asserted that in countries with greater gender equality, girls and women have the freedom to pursue their passions and that "those passions don't always lie within science," implying that women have a fundamental preference for subjects other than science (Khazan, 2018). In this dissertation, I push back on this assertion by focusing on how as early as the preschool years, young children absorb the dominant ideologies of our society (what Bronfenbrenner calls the macrosystem; 1994) which include beliefs that women and non-White people are not naturally brilliant and thus not suited for STEM (Bian et al., 2018; Cvencek et al., 2011; Martinot & Désert, 2007). In combination with early visual and linguistic messages from adults about who belongs in STEM and who does not, young children from underrepresented groups in STEM may choose to pursue non-STEM paths not due to innate preferences, but due to decreased feelings of self-efficacy and relatedness in STEM. Early childhood represents a critical time during which negative stereotypes and bias surrounding STEM may be developing but not yet crystallized, making this developmental period a key time for intervention in educational settings.

How do children learn about and internalize inequities in their social worlds? The papers in this dissertation utilize social-interactionist theory as a primary way by which children acquire knowledge of the world and about science in particular. Social-interactionist theory posits that one critical method for learning in early childhood is through conversations with adults such as caregivers and teachers (e.g., Vygotsky, 1978). The way that adults talk about certain topics may cue children's understanding of their position in society as well as the position of others. Adult language can allow children to conceptualize not only individual actors but also the fact that individuals are part of larger social groups. For example, imagine that a boy solves a math problem correctly and his teacher says, "Boys are good at math," rather than "This boy is good at math." The use of the generic "boys" rather than a term specific to the individual ("this boy") suggests that not only this boy but also all (or at least most) boys are good at math.

Generic language has been shown to be highly useful in category development, in comparison to specific language, and a body of research shows that young children use generic language to shape their understanding of larger categories (e.g., Foster-Hanson et al., 2019). This work indicates the strength of generic statements in shaping children's beliefs about categories. One potential issue with generalizing about a category is that people often rely on limited experience of the category to make the generalization, including sometimes only encountering a single member of the category (Prasada, 2000). This issue may not be problematic when applied to non-social categories (i.e., animals, plants), but research suggests that when generics are used to discuss social categories (i.e. race, gender, ethnicity) it can lead young children to essentialize those categories (Gelman, Ware, & Kleinberg, 2010). Social essentialism is the belief that membership in a category is determined by an underlying "essence" that reflects a deep and stable aspect of the category member (see Rhodes & Mandalaywala, 2017). The propensity to essentialize social categories is viewed in the literature as a cognitive bias about how the world operates that is linked to stereotype formation and bias in young children (e.g., Pauker et al., 2010).

Research suggests generic language as one mechanism by which children's early intuitive social essentialist stance is reinforced (e.g., Rhodes et al., 2018; Foster-Hanson, Leslie, & Rhodes, 2016; Wodak, Leslie, & Rhodes, 2015). For example, consider the generic statement, "Boys are good at math." This statement is similar in form to the statement "kangaroos have pouches," but has real-world implications surrounding gender differences in STEM. As such, generic statements about social categories have also been posited to convey societal expectations about what groups can and should do (e.g., Gelman et al., 2004; Cimpian, 2010). Some research in this area has specifically focused on the category "scientists," conceptualizing "scientists" as a highly homogeneous social group composed of mostly White males that may be essentialized by young children (see Rhodes et al., 2019; NSF, 2023). In particular, researchers have conceptualized "scientists" as a group that children, especially children from underrepresented groups in science such as girls and non-White children, may view as exclusive and separate from themselves (Rhodes et al., 2019; NSF, 2023). This dissertation considers "scientists" to be a group about which children may have preconceived stereotypes that could potentially be either reinforced or ameliorated through certain linguistic and visual cues.

As stated previously, there continues to be a higher percentage of men than women, of White people than non-White people, and of White men than any other group in STEM fields, despite the fact that girls perform better than boys in STEM during the high school years (NSF, 2023; Voyer & Voyer, 2014). Many studies have explored how adult women and older girls respond to male-dominated STEM fields differently than men (e.g., Cheryan et al., 2009; Master et al., 2016; Master et al., 2014). However, a growing body of research investigates how STEM stereotypes impacts young girls' and boys' participation in STEM. Increasingly, people are recognizing early childhood as a potentially critical time for promoting children's interest in STEM. The Building Blocks of STEM Act recently passed in Congress and encourages researchers to focus on increasing the participation of young children (preschool to elementary age) in STEM, with a focus on underrepresented groups. One potential way to understand the early roots of the gender gap in STEM is to consider the messages that children receive from adults and from larger society about who belongs in STEM and who does not. Children are aware of gender stereotypes in STEM and may view STEM fields as being for White men rather than for women and non-White people (Cheryan et al., 2015). This awareness and these stereotypes can be cultivated and magnified by adult language (e.g., Chestnut et al., 2018). Thus, STEM presents a unique lens through which to study how group membership influences decision-making early in development. Research in social cognitive development has shown that when considering how children conceptualize race, children from minority racial groups respond differently to questions about racial preferences than children from dominant racial groups, even when the dominant racial group is smaller in numbers to the minority group (Shutts et al., 2011; Kinzler et al., 2012). It follows that children from underrepresented groups in STEM might similarly have different beliefs about and behaviors related to science learning.

This dissertation proposal explores how children's perceptions, persistence, and sense of belonging in STEM are shaped by the visual and linguistic messages that adults send about who belongs in STEM and who does not. These three papers intentionally focus on early childhood as a critical time to intervene to increase children's STEM engagement and motivation. Additionally, these papers explore the importance of a) fostering a sense of belonging in STEM and b) how even small changes to environmental impact such as images in a storybook or language used to describe a scientist can have a large impact on children's persistence in and beliefs about STEM.

My proposal is guided by three primary research questions:

Paper 1: How does visualizing groups of scientists that vary by gender impact young children's STEM-related persistence and perceptions?

Prior work indicates that children are sensitive to subtle linguistic cues about who belongs in STEM and who does not (e.g., Rhodes et al., 2019). This study examines a perceptual mechanism, that of visualizing scientists situated within larger groups that vary by gender composition, which could influence children's persistence on a science task as well as their judgments of scientists. It seems possible that this kind of visual message about the nature of the group 'scientists' might act similarly to the use of inclusive versus exclusive language related to who can be a scientist. This paper has been published in *Acta Psychologica* (Kumar et al., 2022).

Paper 2: Do young children prefer to learn from scientists who are described as innately brilliant or as hard-working individuals?

Prior work shows that adults are more likely to refer men than women for jobs that require high intelligence and that children are more likely to choose boys for games that are for “really smart” people (Bian et al., 2018). Thus, children show an early biased belief in the idea that boys are innately brilliant. In the context of STEM, these beliefs hold even more weight as scientists as a group are often characterized and believed to be innately brilliant. In Paper 1, I examined how visual cues might impact children’s persistence and judgments in STEM. In Paper 2, I consider how linguistic cues impact children’s decisions about who to learn from. I use the selective trust paradigm to explore how the way scientists are described (as either innately brilliant or effortful) might impact children’s trust in a smart scientist compared to a hard-working scientist.

Paper 3: How does the interaction of visual and linguistic cues about who belongs in STEM influence young children’s beliefs and persistence related to STEM?

In Papers 1 and 2, I focused separately on the impact of visual and linguistic cues on children’s STEM learning and persistence. In Paper 3, I use a storybook methodology to consider how visual and linguistic cues within a science storybook might encourage or discourage children’s STEM interest and persistence. In particular, this paper examines how language type (identity-based or action-based) and the diversity of characters within a science storybook (racially and gender homogeneous or racially and gender diverse) influence children’s STEM beliefs and related behavior.

This dissertation is organized as follows. First, I briefly review relevant literature. Then, I present each paper in full. Next, I explore the Significance and Implications of each paper for social cognitive development and education. I conclude with Future

Directions of this work.

Review of Relevant Literature

*Impact of Stereotypes on STEM Interest and Performan***ce**

Why are women underrepresented in STEM fields? A great deal of research with adults points to negative gender stereotypes in STEM as one barrier to women's participation in STEM. Researchers explored why some STEM fields (e.g., biology, psychology) are more gender balanced than others (e.g., physics, computer science) (Cheryan et al., 2017). Using a sociocultural framework, they explicitly cite a need to investigate the factors that influence girls' preferences and choices related to STEM, rather than assuming that women are simply not interested in certain STEM careers. They posit that masculine cultures in certain STEM fields may signal a lower sense of belonging to women than to men, discouraging women from pursuing STEM subjects like math, physics, and computer science.

In addition to feeling out of place in a masculine culture, women also face negative stereotypes about their abilities and competence in STEM. Prior work has shown the robust effects of stereotype threat on women's performance on math tests (e.g., Spencer et al., 1999). Stereotype threat arises when an individual is engaging in a task for which is the predicament that qualified women face when presented with a set of difficult math problems: unlike equally as qualified men, these women risk being judged by the negative stereotype that women are bad at math if they perform poorly, often leading them to underperform (Spencer et al., 1999). Furthermore, the effects of stereotype threat on women and girls (i.e., underperformance) may reinforce negative attitudes and beliefs about STEM ability, driving capable women away from STEM (Muzzatti & Agnoli, 2007). The effects of stereotype threat have primarily been linked to performance but have also been shown to have a negative effect on women’s interest: for example, women faced with a negative math stereotype showed less interest on a computer science task than women for whom the stereotype threat was nullified (Bian, et al., 2018; Cheryan et al., 2017; Smith et al., 2007). Even changing stereotypical objects in the physical environment, such as hanging a Star Trek poster rather than a neutral nature poster, has been shown to impact negatively women’s interest in STEM (Cheryan, et al., 2009). Cheryan et al. (2007) noted that these differences in gender disparities across STEM fields can be attributed to differing stereotypes about people in each field and the type of work done in each field. For example, computer scientists are stereotyped as socially awkward and as having a singular focus on technology (consider Beyer et al., 2005; Cheryan et al., 2009). Although biologists may be associated with more masculine traits, Cheryan et al. (2007) argue that these associations are relatively less masculine than those associated with computer science, leading to a greater gender balance in biology.

Although much of the research surrounding stereotypes and stereotype threat has involved women, there is a growing body of literature exploring the impact of gender stereotypes in STEM on children’s interest in STEM, their perceptions about boys’ and girls’ ability in STEM, and their perceptions of their own ability in STEM (see Master, 2021 for a review). Elementary age girls have been shown to be susceptible to stereotype threat when performing on mathematics exams (Muzzatti & Agnoli, 2007). In second grade, girls believe that boys are better at math than girls (Cvencek et al., 2011). By late childhood, children believe boys have greater STEM ability than girls (Cvencek et al., 2011; Martinot & Désert, 2007; Passolunghi et al., 2014). These strongly held negative stereotypes can, in turn, negatively impact girls' performance in math and computer science (Master et al., 2017; Master et al., 2014; Huguet & Regner, 2007).

The impact of negative stereotypes on girls' and women's performance in STEM is strong but malleable (e.g., Law et al., 2021; McIntyre et al., 2003; Shachnai et al., 2022). For example, researchers, found women who read stories about successful professional women performed better on a math exam than those who received neither prompt (McIntyre et al., 2003). In early childhood, girls' interest and self-efficacy in STEM can be increased to the level of boys' through experience with that STEM field (e.g., through programming experience, as in Master et al., 2017). Researchers also advocate for diversifying representations of people in STEM, rather than perpetuating narrow, monolithic stereotypes about who belongs in STEM (e.g., by not portraying every computer scientist as a geeky man; Cheryan et al., 2015).

The Effect of Language on Performance in STEM

Conversation between adults and children is one way that stereotypes and essentialist beliefs (i.e., beliefs that members of a category share certain stable traits) are passed down from generation to generation (Rhodes & Tworek, 2012; Segall et al., 2015). Much of this work pertains to the development of children's beliefs about racial and ethnic outgroup members (Segall et al., 2015; Diesendruck & HaLevi, 2006; Birnbaum et al., 2010). Recent research explores how subtle language cues can impact children's persistence and performance in the domain STEM.

In social cognitive development, researchers have noted that the myth that boys are innately brilliant in STEM whereas girls have to work hard to succeed in STEM is one reason that girls may turn away from STEM activities at a young age (see Bian et al., 2018; Chestnut et al., 2018). Prior work has studied how children's understanding of this myth functions, operationalizing this contrast of ability and effort by using the more developmentally appropriate terms "smart" and "hardworking" (e.g., Bian et al., 2018; Bian et al., 2017). Research in this area shows that boys and girls 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). By age six, young girls were less interested than young boys in playing a game for smart children than in playing a game for hardworking children (Bian et al., 2017). Additionally, girls were less likely to perceive their gender as brilliant than boys (Bian et al., 2017). Research looking at children's brilliance beliefs about others have also shown that young children view White men as more brilliant than White women but view Black women as more brilliant than Black men (Jaxon et al., 2019). Taken together, these findings suggest that children's early associations between brilliance and STEM impact their choices as well as their perceptions of others.

As mentioned earlier in the introduction, the use of generic language can negatively influence children's performance and motivation. For example, researchers have found that following criticism, children given generic praise (e.g., "You are a good drawer") were less interested in and more avoidant of drawing than children provided with specific praise (e.g., "You did a good job drawing") (Cimpian et al., 2007). In the domain of science, Rhodes et al. (2019) found that five- to seven-year-old girls' but not boys' persistence on a science task decreased when the task was introduced using identity-based language (e.g., "We're being scientists today") than when the task was introduced by using action-based language (e.g., "We're doing science today"). In this paper, researchers used different terminology (i.e., action-based versus identity-based rather than specific versus generic language) to explain the differential impact of language on children's persistence, but the fundamental underlying mechanism in this line of research is closely related to the mechanism underlying children's performance when exposed to generic language. Identity-based language and generic language emphasize that members of a group share essential properties that may be exclusive to individuals who are not group members. When children hear these language types, they may consider whether or not they could be part of the group in question; if they determine that they could not realistically be part of the group, then they might be less motivated to persist. In this case, upon hearing identity-based language, girls may have reflected and determined that they could not plausibly be a scientist (Rhodes et al., 2019). Follow-ups to this work have shown that exposure to identity-based language also negatively impacts children's science interest and feelings of self-efficacy and that students of teachers who have been trained to use action-based language persisted longer on a science task than students of teachers who were not trained (Lei et al. 2019; Rhodes et al., 2020).

Social Group Membership and STEM Motivation

This body of research on linguistic cues points to an underlying mechanism that may have a strong impact on children's participation in STEM: feeling like you are part of the group. Within this framework, White children and boys may feel more able to be a group member whereas girls and non-White people may feel less able to be a group member. From a young age, humans have a tendency to categorize the world around them (consider Piaget's schemas; Piaget, 1964). The field of social cognitive development further posits that this predisposition for categorization extends to the categorization of social groups. Core knowledge theory suggests that infants are born with a handful of cognitive knowledge systems that allow them to represent objects, action, space, and number and that as children grow, they build on these fundamental systems (Spelke, 2000). Recent work related to core knowledge theory proposes that infants also have a fifth core knowledge system that allows them to represent social partners, providing a very early concept of "us and them:" the idea that some people are part of our social group and others are not. In infancy and early childhood, this conception of ingroups and outgroups has been shown to influence children's perceptions of themselves and others (e.g., Mahajan & Wynn, 2012; Powell & Spelke, 2013).

Group markers are thus powerful cues that lead children to make inferences about different groups. The strength of group markers is emphasized in work showing that children prefer ingroup members over outgroup members, even when markers of group membership are minimal and randomly assigned (Billig & Tajfel, 1973; Dunham et al., 2011). Additionally, preschool age children are sensitive to more naturalistic group markers like accent and race, strongly preferring native-accent speakers over foreign accent speakers (e.g., Kinzler et al., 2011) and, when they are from majority race groups, members of their own race to members of different races (e.g., Baron & Banaji, 2006; Kinzler et al., 2009). When considering gender as a social category, research indicates that children have a strong preference for children who share their gender, preferring to be friends with, to imitate, and to trust people of the same gender over different-gender people (Serbin et al., 1994; Grace et al., 2008; Terrier et al., 2016).

This sensitivity to group membership, even when the markers of membership are minimal, may be rooted in children's essentialist thought about social category membership. By around three or four years, children begin to hold these essentialist beliefs, such as the belief that category members will share certain properties with each other even if they are different in some ways and the belief that membership in a category is stable and intrinsic (Rhodes & Mandalaywala, 2017 term these homogeneity and stability, respectively). Children then use these beliefs to make inferences about category members. For example, children predict that a baby who is born to parents who speak one language but who is adopted by parents who speak another language will grow up to speak the language of their birth parents, suggesting that children hold strong essentialist beliefs about the stability of language development (Hirschfeld & Gelman, 1997).

Current research suggests that children's social essentialist beliefs rely on certain cognitive biases (e.g., a tendency to expect causal determinism) and are actively constructed as children work to make sense of their social environments (Rhodes & Mandalaywala, 2017). Children's membership in specific groups, in addition to their social environments, impacts the construction of their essentialist beliefs. For example, research has found that Black children in the United States develop an essentialist understanding of the stability of race over time much earlier than White children (Kinzler & Dautel, 2012). It seemed likely that this finding occurred because of the minoritized status of Black people in the United States, but another confounding possibility was that in addition to being the dominant group, White people are also the larger group in terms of numbers compared to Black people. Thus, it was possible that Black children were more aware of the stability of race due to an earlier recognition that there were fewer Black people than White people in the United States, not only due to the lower status of Black people in this country. However, research has explored the social context of South Africa, where Black people are the majority race of the country but have historically been the lower status racial group as compared to White people. In that context, researchers found that young Black children had strong preferences for White individuals and for English speakers, suggesting that these differences were due to the historically lower status of Black people in South Africa, not to a smaller population (Shutts et al., 2011; Kinzler et al., 2012). Taken together, these findings provide insight into how children's biases are highly dependent on societal context and that children are aware of how their own social group membership relates to others.

Returning specifically to the domain of STEM, in which girls and non-White children might be considered a lower status and minoritized group compared to White men who are the dominant group in STEM, it follows that encouraging children's beliefs that they can be part of the group "scientist" would be critical to promoting their participation in STEM. Indeed, young children who were assigned to a minimal and arbitrary group showed increased interest and participation on a task (Master & Walton, 2013). Children who were placed in a group were more interested, more accurate, and had higher self-efficacy after completing a STEM task than children who worked on the task as individuals (Master et al., 2015). Additionally, young children who believed in negative STEM stereotypes about their gender group rated their own ability lower than children who generally believed that their gender was good at math (Master et al., 2021).

Achievement Motivation in STEM

How do children decide whether to pursue a challenging task or not? This question is critical in the domain of science because failure and setbacks are an inherent part of the scientific process. Thus, children's response to and beliefs about failure in general and in the science context can potentially mediate children's decisions to pursue science or not. For example, if a child attempts to make a lightbulb turn on with a Snap Circuits kit, it might take multiple attempts before they succeed. However, if they become frustrated, angry, or discouraged that the lightbulb does not turn on after their first attempt, they might decide that they are not interested in continuing to play with the Snap Circuits anymore. The field of achievement motivation explores this question of how children respond to setbacks and challenges. Researchers consider achievement motivation to the be "the study of goal-directed behavior in educational settings" (Bempechat & Mirny, 2005). Today, achievement motivation is considered through the lens of social cognition, viewing motivation not as a monolith but as a "constellation of beliefs and behavior" that affects how children think about their learning experiences

(Bempechat & Mirny, 2005). Children’s decisions to pursue difficult tasks in school (or their decision not to) are impacted by their beliefs about intelligence and their attributions of success and failure. One factor that can impact children’s achievement motivation is their belief about whether intelligence is a stable trait or not (Dweck, 2008). Fixed mindset is the belief that intelligence is a stable trait that an individual cannot change over time; growth mindset is the belief that intelligence is not a static facet of the self and that in fact you can increase your intelligence over time (Dweck, 2008).

Research on mindset has been explored across many domains. Some prior work has specifically explored how mindset relates to performance in science. For example, researchers have found that middle school students with a growth mindset focused scored higher grades in math than students with a fixed mindset (Blackwell et al., 2007). Additionally, college students with a growth mindset did better in chemistry class than students with a fixed mindset (Grant & Dweck, 2003). Much of this work has been done with older children and adults. For example, research with high school students has shown that students who read about famous scientists’ struggles did better in science class than students who read about those scientists’ achievements, but that their mindset beliefs were not impacted (Lin-Siegler et al., 2016). However, recent work has explored how mindset relates to STEM interest and persistence in early childhood. Work with four- to five-year-old children has shown that children’s persistence but not their explicit responses to a survey investigating their mastery motivation was influenced depending on whether they read a storybook about famous scientists who struggled or famous scientists who effortlessly achieved success (Kumar, Haber, et al., 2021). Although in the previous studies neither children’s mindset nor their mastery motivation was impacted by condition, it seems possible that these null findings occurred because the storybooks and paragraphs about scientists were too far removed from children’s self-concepts to impact their explicit understanding of their own motivation. Additionally, in recent work researchers found that participants 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. Overall, this dissertation proposal considers mindset to be a potentially malleable factor that can both impact children’s performance and beliefs about science but also can be shifted through intervention.

CHAPTER TWO

Paper 1: The impact of visualizing the group on children’s persistence in and perceptions of STEM

Introduction

Groups of scientists in STEM fields are largely homogeneous and disproportionately composed of males (NSF, 2021). This underrepresentation of women in STEM fields remains the norm in the United States, especially in physics, computer science, and engineering (NSF, 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 & Walton, 2013; Master et al., 2017). 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 et al., 2021).

The current study aims to investigate a related learning mechanism 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.

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 & Martinot, 2011; 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.

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 et al., 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., 2017; Master et al., 2014). 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 et al., 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, some research has 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.

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).

Method

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 minutes 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.

Procedure

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 Figure 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 Figure 2.1).

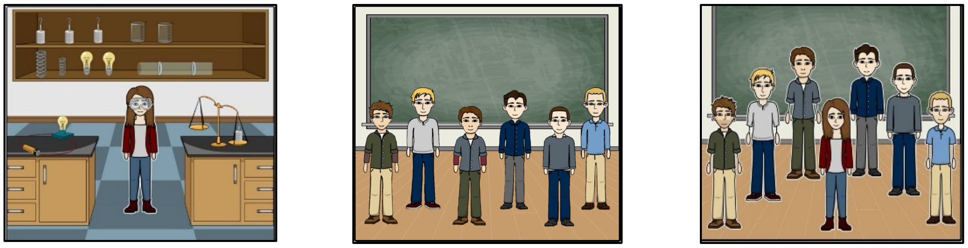

Figure 2.1. Example of the Female/All-Male condition.

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, Kumar et al., 2022; Leonard et al., 2021). For this study, we defined persistence as children's 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 Figure 2.2). 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.

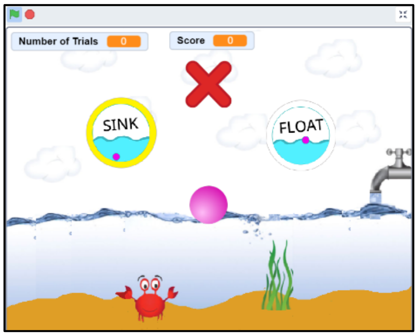

Figure 2.2. Example of the first trial on the sink or float task.

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.

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 2.1). 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.

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"	

Table 2.1. Coding scheme and examples.

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.

Results

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 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 Figure 2.3). 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 Figure 2.4). 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 ($\beta = -0.30$, $SE = .41$, $p = 0.47$).

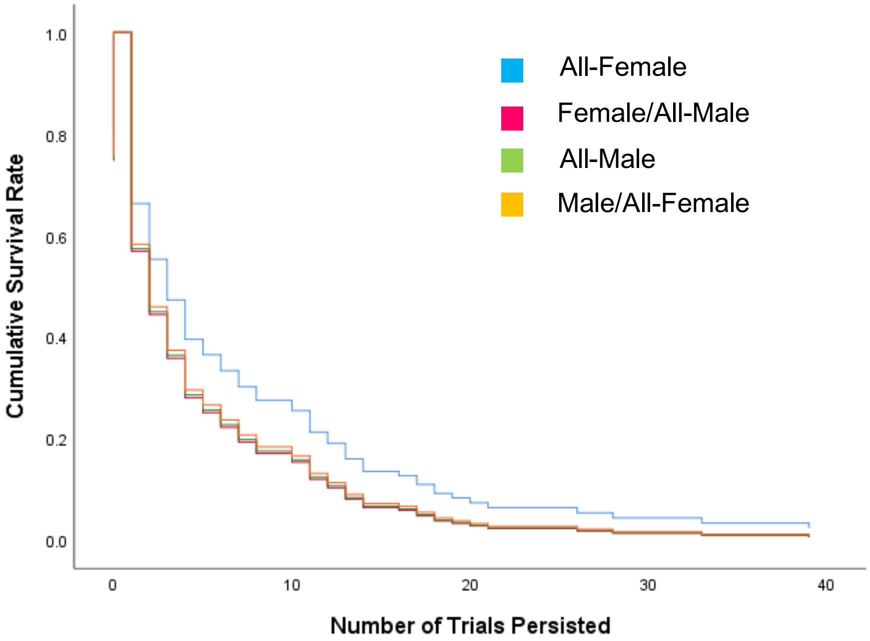

Figure 2.3. Survival Plot of Persistence by Condition

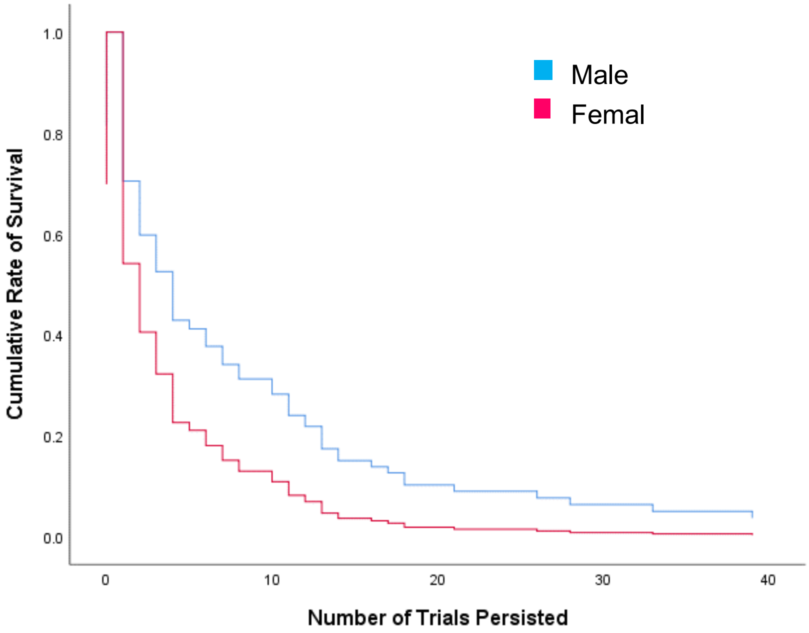

Figure 2.4. Survival plot of persistence by gender.

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 Figure 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 (*β* = 0.90, *SE* = .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 (*β* = 0.678, *SE* = 0.46, *p* = 0.14; see Figure 2.5).

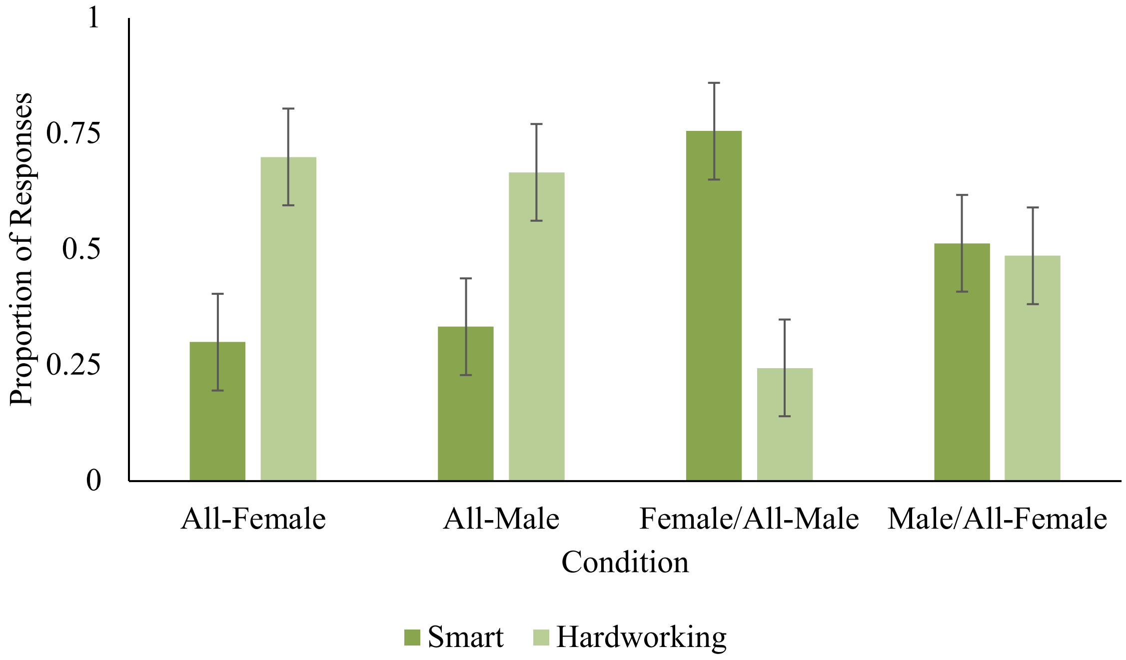

Figure 2.5. Proportion of children's trait attributions across the four conditions with standard error bars.

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

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

Table 2.2. Codes mentioning effort, ability, and occupation by child's trait attribution judgment (smart or hardworking).

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 2.3). 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 2.3). 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 ($X^2(6, N = 130) = 11.92, p = 0.06$).

	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%

Table 2.3. Codes mentioning effort, ability, and occupation by condition.

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.

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.

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., 2008). 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.

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.'s (2019) 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.

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 et al., 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.

Implications Across the Lifespan

To return to one of the central themes of this paper, women remain underrepresented in STEM fields (NSF, 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; NSF, 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.

CHAPTER THREE

Paper 2: Failure is an option: young children's selective trust in ability-oriented versus effort-oriented scientists

Introduction

In a 2019 TED Talk, astrophysicist Erika Hamden discussed her efforts at installing a telescope near the edge of the universe as a method for collecting information about how stars are formed. Rather than focusing on her exceptional achievements, Hamden highlighted the ups and downs of the project, noting that failure is an inevitable part of scientific advancement. This type of transparency is rare in science, especially sciences like physics and chemistry where the overwhelmingly White and male scientists are frequently viewed as brilliant geniuses rather than hard workers (see Leslie et al., 2015). The myth that only naturally brilliant people can succeed in these fields may lead those who experience failure to abandon the profession rather than to persist (consider NSF, 2023; see also Chestnut et al., 2018). This myth may be perpetuated through the language that adults use when discussing their own scientific paths. Although researchers like Hamden may highlight the effort behind her success, other scientists, or lay people who are discussing these scientists, may be more prone to emphasizing their accomplishments and accolades. For example, when a researcher presents an invited talk, they are typically introduced by highlighting awards and accomplishments on their CV, rather than by highlighting the rejections and challenges the researcher faced on the journey to success. In this way, the language that adults use may shape children's perceptions about who belongs in science and who can succeed as a scientist. The current study uses the selective trust paradigm to explore how four- to seven-year-old children perceive and respond to scientists who explicitly discuss their struggles, as compared to scientists who express only apparently effortless successes.

Before turning to the current study, I first review relevant research focusing on how children's perceptions of effort and ability shape their beliefs and behavior in STEM, as well as research using the selective trust paradigm.

Perceptions of Effort, Ability, and Intelligence

In early childhood, six-year-old children have been shown to endorse beliefs that boys have a greater interest in STEM than girls; by middle to late childhood, children have been shown to believe that boys also have a greater ability in STEM than girls (Cvencek et al., 2011; Martinot & Désert, 2007; Passolunghi et al., 2014). Even in early childhood, when girls and boys have not developed strong beliefs that boys are better than girls in STEM, children's decision making appears to be impacted by beliefs about science ability (see Master, 2021 for a review). For example, in one study, six-year-old girls chose to play a game for children who are hardworking rather than a game for children who are smart (Bian, 2017; Bian et al., 2018). Additionally, six-year-old children who endorsed the idea that their gender group (either boys or girls) was bad at math rated their math ability lower than children who endorsed the idea that their gender group was good at math (Master et al., 2021). Similarly, six-year-old girls who believed negative stereotypes about women in STEM showed decreased interest in STEM fields than girls who did not strongly endorse those negative stereotypes (Master et al., 2021). Taken together, these findings suggest that perceptions about brilliance and effort in

STEM impact children's related behavior and beliefs.

Much of the prior work in this area has focused on adults' and adolescents' perceptions of STEM fields, especially fields like physics, engineering, computer science, chemistry, and math, which are particularly male dominated (e.g., Cheryan et al., 2009; Cheryan et al., 2011; Cheryan et al., 2017; Master et al., 2014; NSF, 2023). For example, some research has shown that exposing high school students to scientists' efforts, as opposed to their achievements, yielded better grades in science class (Lin-Siegler et al., 2016).

More recently, there have been efforts to explore young children's perceptions of science and scientists, with an emphasis on how explanations for a scientist's success (either due to natural ability or hard work) can impact perceptions of and performance in STEM (Master, 2021). One review paper focusing on effective role models in STEM suggests that role models in STEM be portrayed as competent, similar to students, belonging to underrepresented groups in STEM, and having attained success through attainable means (Gladstone & Cimpian, 2021). This review further found very little work related to how children in preschool and early elementary school respond to role models in STEM. Some recent work has found that four- to seven-year-old children learning about successful scientists and being given the opportunity to pretend to be that scientist are potential ways to increase children's persistence on a STEM task and feelings of self-efficacy (Shachnai et al., 2022). Additionally, four- and five-year-old children who hear about a famous scientist's efforts have been shown to persist longer at a task than children who hear about the scientist's achievements and accolades (Haber, Kumar, et al., 2022). In terms of perceptions of STEM role models, there is some evidence that when fifth graders were shown that a role model's success in math was due to hard work, children performed better on a challenging math test than when the role model's success was attributed to hard work (Bagès & Martinot, 2011). Additionally, four- to six-year-old children's attributions of a scientist's success have been shown to change depending on group context; for example, scientists within same-gender groups were viewed as more hardworking than smart (Kumar et al., 2022).

In the current study, I am interested in not only whether children prefer to learn from a smart or hardworking individual, but also in how children's preferences might relate to their beliefs about intelligence, such as whether they believe intelligence is a stable or a malleable trait (Dweck, 2008; Dweck & Leggett, 1988). For example, it seems possible that children who prefer to learn from a smart person rather than a hardworking person might view intelligence as a fixed trait and endorse a fixed mindset rather than a growth mindset. Research with older children and adults has shown that students' mindset (either fixed or growth) is related to their grades, with students with a growth mindset achieving higher grades in math and science than students with a fixed mindset (Blackwell et al., 2007; Grant & Dweck, 2003). Although in prior work examining the relation between motivation and scientist role models, neither children's mindset nor their mastery motivation was impacted by condition, these null findings may have occurred because the storybooks and paragraphs about scientists were too far removed from children's self-concepts to impact their explicit understanding of their own motivation (Haber, Kumar et al., 2022; Lin-Siegler et al., 2016). In the current study, my goal is to explore potential links between mindset and selective learning preference informants who are described as either smart or hardworking.

Selective Trust Paradigm

Social interactionist theories recognize that children learn not just from their own first-hand experience, but also from others. Over the past 20 years, researchers have increasingly recognized that children do not learn equally well from all learning partners – they selectively prefer to learn from some partners over others (cf. selective trust; Harris et al, 2018). One popular methodological approach has been the use of the selective trust paradigm. Over the past decade and a half, the selective trust paradigm has existed as a robust method for studying from whom children prefer to learn when given a forced choice (Corriveau et al., 2009; Harris & Corriveau, 2011; Pasquini et al., 2007). Selective trust studies center a Vygotskian lens, acknowledging the fact that children learn not just through interaction with their environments, but also through interactions with adults (e.g., Vygotsky, 1978). This body of research emphasizes that young children are attuned to subtle differences in informants' behavior and language, demonstrating preferences for individuals who are accurate rather than inaccurate, competent rather than incompetent, and expert rather than novice (e.g., Asaba et al., 2021; Corriveau et al., 2013; Johnston et al., 2015; Kurkul & Corriveau, 2014; Landrum et al., 2013; Sobel & Corriveau, 2010).

Prior research with young children has operationalized ideas of "brilliance" versus "effort" by using the terms "smart" and "hardworking" to describe people and objects related to science (Bian et al., 2018; Jaxon et al., 2019). Some research that has used “smart” as a proxy for brilliance or intellectual ability has found that children’s gender brilliance stereotypes change depending on a person’s race and gender (e.g., Jaxon et al., 2019; Shu et al., 2022). For example, 5- to 7-year-old children associate White men (but not women) with brilliance and associate Black women (but not men) with brilliance (Jaxon et al., 2019). These findings demonstrate that even young children have nuanced perceptions of others’ brilliance status. However, to the best of our knowledge, no research has explored whether children prefer to learn from a smart person or a hardworking person. More specifically, I examined this question within the domain of science because ideas of ability and effort are loaded in this domain. Paradoxically, although scientists are viewed as a special, brilliant group, the scientific method inherently assumes that experiments will fail and need to be redesigned (Bian et al., 2017). In the next section, I briefly explore research on children’s perceptions of ability and effort within the domain of science.

The Current Study

Through the lens of the selective trust paradigm, the current study investigates how emphasis on ability and achievement rather than effort relates to children’s selective trust, mindset, and persistence in the domain of science. I asked three primary research questions. First, do young children prefer to learn from a scientist described using ability-focused language or from a scientist described using effort-focused language? Second, is there a relation between children’s decision to selectively trust an achievement-focused or effort-focused scientist and their beliefs about themselves, others, and intelligence? Third, does learning from an ability-focused scientist or from an effort-focused scientist impact children’s persistence on a challenging task? In addition to these three main research questions, I also explored potential individual differences by child gender and age.

Predictions

I anticipated two possible patterns of results for children’s responses on the selective trust task. First, prior work has emphasized that children and adolescents who are presented with a story focusing on effort demonstrate enhanced science grades and a greater willingness to persist on a task (Haber, Kumar, et al., 2022; Lin-Siegler et al., 2016). Accordingly, children might be more likely to choose to learn new information from the Effort Informant rather than from the Ability Informant. By contrast, other work has shown that children selectively trust accurate, competent, and expert individuals (e.g., Ma et al., 2022; Sobel & Corriveau, 2010). Although I was careful to convey that the two informants were equals in every way except in the apparent ease of their paths as scientists, it is possible that children would interpret the challenges that the Effort Informant discusses as a sign of incompetence. On this hypothesis, children should be more likely to choose to learn from the Ability Informant if they interpreted that informant as more competent, accurate, or expert.

Additionally, I predicted age- and gender-related differences on the selective trust task. Regarding gender, I hypothesized that boys might prefer to learn from the Ability Informant more than would girls. This prediction was based on work indicating that by age six, young girls are less likely to believe that members of their own gender are smart than young boys (Bian et al., 2017). This study examined four- to seven-year-old children. Prior work has shown developmental change in children's beliefs about brilliance across this age range, with six-year-old girls, but not five-year-old girls, less likely to associate brilliance with their own gender than six-year-old boys (Bian et al., 2017). Still, recent work examining four- to seven-year-old children's social preferences has shown that children in this age group showed a preference for a naturally brilliant individual. This work compared child participants to a group of adult participants rather than considering age as a continuous variable and thus did not explore developmental changes in children's preferences from age four to age seven (Ma et al., 2022). Accordingly, I had no strong predictions as to possible developmental changes in informant preference between ages four and seven.

Regarding the persistence task, I anticipated that children who heard about the game via the Effort Informant would persist longer at the task than children who heard about it via the Ability Informant. Moreover, following a similar pattern of results from Rhodes et al. (2019) regarding gender differences on a persistence task, I predicted that boys' persistence would be similar across conditions whereas girls would persist longer when learning from an effort-focused scientist than from an achievement-focused scientist.

Method

Participants

This study included 102 4- to- 7-year-old children (*Mage* = 71 months, *SD* = 16 months; 48 female). Three children were excluded due to experimenter error. A power analysis in G*Power indicated that this sample size provides sufficient power of 0.80 to conduct the planned mixed effects linear regression analyses with a medium effect size (Faul et al., 2009). I chose this age-range based on prior work indicating developmental differences in children's responses to brilliance versus effort across ages 4 to 7 years (e.g., Bian et al., 2017). Participants were recruited through online advertisements. All data collection was conducted online via Zoom.

In addition to providing consent to run the study, participants were asked to complete a demographic survey including information about race, ethnicity, family income, and level of parental education. The consent form and survey were approved by the Boston University Institutional Review Board. Seventy-four percent of participating families reported some demographic information. Of these families, 83% of families included at least one parent with a bachelor's degree or higher and 76% earned $50,000 or more in annual income. Sixty-five percent of families identified as White/Caucasian, with 15% identifying as Asian, 13% identifying as mixed race, 5% identifying as Hispanic, 3% identifying as Black, and 3% identifying as other.

Design

Children were invited to participate in three phases of the study: a selective trust task, a mindset measure, and persistence task.

Selective Trust Task

Children were introduced to two White, female scientists. The images had been used in prior selective trust literature (Corriveau & Kurkul, 2014). The scientists were described in terms of their ability and effort. Prior literature has shown that children persist equally as long when exposed to a scientist who has struggled regardless of the content of the struggle (Haber, Kumar, et al., 2022; Lin-Siegler et al., 2016). Thus, I chose to focus on the scientist's intellectual rather than personal struggles. The scientists were matched in terms of accolades and position (e.g., both scientists were described as getting the highest grades on their science tests). The only difference between the informants was in the description of their path to achievement.

Because data were collected via Zoom, the images of each informant included colored border (either red or blue) to allow children to provide a clear indicator of the informant they had selected without pointing. The researcher alternated between descriptions of each scientist. To start, the researcher described the scientists' study habits, saying first, "The scientist in the blue box didn't have to study very hard to do well in school" and then, "The scientist in the red box did have to study very hard to do well in school." Next, the researcher described the scientists' experiments, saying first, "The scientist in the blue box did experiments that always worked the first time she tried them" and then, "The scientist in the red box had to try many different experiments before one worked." The researcher then emphasized that both scientists "always got the highest score on their science tests." Finally, the researcher explicitly used ability and effort labels, telling children that "the scientist in the blue box is really, really smart" and "the scientist in the red box is really, really hardworking." Color order and the order in which children were introduced to the smart and hardworking scientist were counterbalanced.

Immediately following this introduction, children were asked two sets of four Selective Trust Questions (one set of 4 object label endorsements and one set of 4 novel science question ask trials) as well as one set of five Explicit Judgment Questions (see Table 3.1). Researchers noted whether the child endorsed the information provided by the Effort Informant or the Ability Informant on each trial. Additionally, after each science question ask trial and explicit judgment question children were invited to justify their response as to why they chose one informant over the other.

Question Type	Description	Example
Object Label Endorsements	Children are presented with a novel object. Informants are asked what they would call the object. Experimenter then asks child what they think the object is called.	“This informant calls the object a ‘dax,’ the other calls it a ‘nez.’ Do you think the object is called a ‘dax’ or a ‘nez?’”
Science Question Ask Trials	Children are asked to imagine that they have a science question and which informant they would want to ask.	“Imagine that you want to ask, ‘Why is the sky blue?’ Which informant would you ask? Why?”
Explicit Judgment Questions	Children are asked to decide which informant is most likely to have done the action described.	One of the scientists won an award for a new science invention. Who won the award? Why?

Table 3.1. Description of selective trust questions.

Science Question Ask Trial Justifications and Explicit Judgment Coding Scheme

To make sense of children’s justifications to the ask trials and explicit judgment questions, justifications were coded using a coding scheme from prior work on children’s perceptions and judgments of scientists (Kumar et al., 2023). Justifications coded as *uninformative* included no response, irrelevant responses, or children citing that they did not know. *Uninformative* responses were mutually exclusive, meaning that if a response received an *uninformative* code, it did not receive any other code (see Table 3.2). Other responses were coded as references to *effort*, references to *natural ability*, references to *physical attributes*, references to a character's *personality traits*, references to *occupation*, and references to the child or character's *intrinsic preferences* (see Table 3.2 for examples). These codes were not mutually exclusive. To ensure reliable coding, two coders first coded 6% of the data separately. Coders agreed on 98% of codes (*kappa* = 0.96), indicating very high levels of agreement. Disagreements were resolved through discussion.

Code	Example	Mutually Exclusive?
Uninformative	"I don't know."	Yes
Effort	"She's really hardworking."	No
Ability	"She's really smart."	No
Occupation	"She is a scientist."	No
Physical Attributes	"Her hair's long."	No
Personality Traits	"She looks happier."	No
Intrinsic Motivation	"Blue is my favorite color."	No

Table 3.2. Selective trust coding scheme and examples.

Mindset Measure

Children were told two statements, one which aligned with a growth mindset ("Some kids say you can get smarter and smarter all the time") and one that aligned with a fixed mindset ("Other kids say how smart you are stays pretty much the same"). They were then asked which kids they agreed with and why (Bempechat et al., 1991).

Mindset Coding Scheme

Recall that children were asked to justify their response to the mindset question.

Justifications were coded using a coding scheme developed through a bottom-up process of reading children's justifications and then considering themes that arose frequently. Justifications coded as *uninformative* included no response, irrelevant responses, or children citing that they did not know why. *Uninformative* responses were mutually exclusive, meaning that if a response received an *uninformative* code, it did not receive any other code (see Table 3.3). Other responses were coded as references to *learning*, especially as a way to gain intelligence; references to the *stability of intelligence*, which considered intelligence as something that you are born with; and references to *personal connections or examples* that illustrated children's response. These codes were not mutually exclusive (see Table 3.3 for examples). To ensure reliable coding, two coders first coded 19% of the data separately. Coders agreed on 86% of codes (*kappa* = 0.72), indicating good levels of agreement. Disagreements were resolved through discussion.

Code	**Example**	**Mutually Exclusive?**
Uninformative	"I don't know."	Yes
Learning	"Every time you learn something new, you get smarter."	No
Stability of Intelligence	"Maybe you can't get smarter and smarter."	No
Personal Connections/Examples	"I didn't know the stuff I learned until I went to school."	No

Table 3.3. Mindset coding scheme and examples.

Persistence Task

Finally, children were reintroduced to either the Effort Informant (*n* = 41) or the Ability Informant (*n* = 56), including reminders of whether they were smart or hardworking. The reminders were a repetition of how the child had been introduced to the character initially. For example, for the Ability Informant, children were told, "Remember, the scientist in the red (or blue) box didn't have to study hard to do well in school; she did experiments that always worked the first time she tried them; and she was really, really smart." To remind the child of who each informant was, the experimenter repeated their description of the scientist from earlier in the study, describing the informant as either smart or hardworking (e.g., "Remember, this scientist is really, really smart") and the experimenter explained that they had a science game and children were invited to play the game. The game measured children's persistence by inviting children to predict whether objects would sink or float in water. The game was rigged such that on the first trial, all children were incorrect. After the first trial, responses were fair. Additionally, after each trial the researcher informed children that they had responded correctly or incorrectly and asked children if they wanted to keep playing the science game or do something else (following Rhodes et al., 2019). Researchers measured the number of trials children persisted following the first incorrect trial. The maximum number of trials was 16.

Results

First, I conducted preliminary analyses to evaluate whether or not children's responses on the selective trust task were impacted by Counterbalancing (i.e., the order or the informant and image border color). I conducted two generalized linear models with participant and trial as random effects and counterbalancing as a fixed effect, one for the object label endorsements and one for the ask trials. Analyses indicated that children's responses on the selective trust task were not impacted by Counterbalancing ($\beta 2Q = -0.17$, $SE = 0.28$, $p = 0.53$; $\beta 3Q = -0.07$, $SE = 0.28$, $p = 0.79$; $\beta 4Q = 0.20$, $SE = 0.31$, $p = 0.53$; $\beta 2L = -0.63$, $SE = 0.35$, $p = 0.07$; $\beta 3L = 0.19$, $SE = 0.35$, $p = 0.59$; $\beta 4L = 0.05$, $SE = 0.38$, $p = 0.90$).

Following this preliminary analysis, I examined whether children's endorsements differed by Child Age or Child Gender for the Object Label Endorsements and Science Question Ask Trials. There were no differences in children's selective endorsements by Child Age or Child Gender ($\beta AgeQ = 0.00$, $SE = 0.00$, $p = 0.61$; $\beta GenderQ = -0.04$, $SE = 0.21$, $p = 0.86$; $\beta AgeL = -0.01$, $SE = 0.01$, $p = 0.46$; $\beta GenderL = 0.08$, $SE = 0.25$, $p = 0.31$). Accordingly, the following analyses collapse across Child Age, Child Gender, and Counterbalancing.

Selective Trust Endorsements

First, I explored children's selective preference for the information provided by the Ability Informant or the Effort Informant for either Object Label Endorsements or Science Question Ask Trials. To examine whether children's preference differed on the label endorsement trials, I conducted a mixed effects logistic regression with participant as a random factor and endorsement (Ability or Effort Informant) as the outcome variable. Results indicated that for the label endorsement trials, there was no difference in the likelihood of children preferring one informant over the other ($\beta label = 0.18$, $SE =$

0.12, $p = 0.16$). To examine whether children's preference differed on the ask trials, I conducted a mixed effects logistic regression with participant as a random factor and endorsement (Ability or Effort Informant) as the outcome variable. Results indicated that for the ask trials, children were significantly more likely to prefer asking the Ability Informant a science question than to prefer asking the Effort Informant ($\beta ask = 0.36$, $SE = 0.10$, $p < 0.001$).

Coding Justifications for Science Question Ask Trial Endorsements

Children were invited to choose to which informant they would prefer to pose a science question across four trials. Immediately following their choice, children were asked to justify their response (i.e., to state why they had chosen either the Ability Informant or the Effort Informant). Using the coding scheme detailed in the Method, children's responses to the four justification questions were coded. There were a total of 398 justifications. Of these, 33% were *uninformative*, leaving 266 informative responses. Of the informative responses, 18% referenced *effort*, 64% referenced *ability*, 19% referenced *physical attributes*, 0.3% referenced *personality traits*, 1% referenced *occupation*, 5% referenced *intrinsic preferences*.

I then separated justifications by whether the participant had preferred to ask the Ability Informant or the Effort Informant. For participants who preferred the Effort Informant, 38% of responses were uninformative, leaving 110 informative justifications. Of these informative justifications, 39% referenced *effort*, 25% referenced *ability*, 29% referenced *physical attributes*, 0% referenced *personality traits*, 0% referenced *occupation*, and 6% referenced *intrinsic preferences*. For participants who preferred the

Ability Informant, 26% of responses were uninformative, leaving 176 informative justifications. Of these informative justifications, 2% referenced *effort*, 81% referenced *ability*, 11% referenced *physical attributes*, 0.6% referenced *personality traits*, 1.7% referenced *occupation*, and 3% referenced *intrinsic preferences*.

Significantly more participants referenced *effort* after endorsing the Effort Informant than after endorsing the Ability Informant ($z = -8.17$, $p < 0.001$). Further, significantly more references to *ability* were made when participants justified the choice of the Ability Informant than when participants justified the choice of the Effort Informant ($z = 9.25$, $p < 0.001$). There was also a significant difference in justifications referencing *physical attributes*, with trials endorsing the Effort Informant including significantly more references to *physical attributes* in their justifications than trials endorsing the Ability Informant ($z = -3.78$, $p < 0.001$).

Responses to Explicit Judgment Questions

Next, I examined children's responses to the five explicit judgment questions. Two of the questions ("Which scientist is really smart?" and "Which scientist is really hardworking?") served as memory checks to ensure that children were tracking which scientist was the Ability Informant and which was the Effort Informant. I found that children were more likely to say that the Ability Informant was smart than hardworking and more likely to say that the Effort Informant was hardworking than smart ($zsmart = 9.65$, $p < 0.001$; $zhardworking = 12.41$, $p < 0.001$). Children were more likely to endorse the Ability Informant when asked which scientist they would ask more questions ($zquestion = 4.53$, $p < 0.001$). Children were as likely to believe that the Ability

Informant had won an award for a new science invention as the Effort Informant. Additionally, children were as likely to say that the Ability Informant was like them as to say that the Effort Informant was like them ($z_{similar} = 0.56$, $p > 0.05$). Table 3.4 shows percentages of participants endorsing each informant for each explicit judgment question.

Question	Percentage Endorsing Ability Informant	Percentage Endorsing Effort Informant
EJQ1: One of the scientists won an award for a new science invention. Who won the award?	53%	47%
EJQ2: One of the scientists is really smart. Which one is really smart?	85%	15%
EJQ3: One of the scientists is really hardworking. Which one is really hardworking?	5%	95%
EJQ4: If you have more science questions, which scientist would you ask to answer your question?	66%	34%
EJQ5: Which of the scientists is more like you?	52%	48%

Table 3.4. Percentage of participants endorsing each informant for explicit judgment questions.

Coding Explicit Judgment Question Justifications

Here, I focus on children's responses to three of the explicit judgment questions: which scientist won an award, which scientist would you ask more questions, and which scientist is more like you. I used the same coding scheme used above.

Which scientist won an award? Using the coding scheme detailed in the Method, children's responses to the justification question were coded. There were a total of 103 justifications. Of these, 28% were *uninformative*, leaving 74 informative responses. Of the informative responses, 36% referenced *effort*, 57% referenced *ability*, 3% referenced *physical attributes*, 0% referenced *personality traits*, 1% referenced *occupation*, 3% referenced *intrinsic preferences*.

Again, I explored differences in justification codes based on whether the response was to endorse the Ability Informant or to endorse the Effort Informant. When children endorsed the Effort Informant, 28% of responses were uninformative. Of informative responses, 74% referenced *effort*, 18% referenced *ability*, 3% referenced *physical attributes*, 0% referenced *personality traits*, 1% referenced *occupation*, 6% referenced *intrinsic preferences*. When children endorsed the Ability Informant, 25% of responses were uninformative. Of informative responses, 5% referenced *effort*, 90% referenced *ability*, 2.5% referenced *physical attributes*, 0% referenced *personality traits*, 2.5% referenced *occupation*, 0% referenced *intrinsic preferences*.

Significantly more participants referenced *effort* in their justifications after endorsing the Effort Informant as the scientist they thought would win an award than the Ability Informant ($z = 6.10, p < 0.001$). Significantly more participants referenced *ability* in their justifications after endorsing the Ability Informant as the scientist they thought would win an award than the Effort Informant ($z = -6.26, p < 0.001$).

Which scientist would you ask more questions? Using the coding scheme detailed in the Method, children's responses to the justification question were coded. There was a total of 110 justifications. Of these, 37% were *uninformative*, leaving 69 informative responses. Of the informative responses, 10% referenced *effort*, 71%

referenced *ability*, 10% referenced *physical attributes*, 0% referenced *personality traits*, 0% referenced *occupation*, 9% referenced *intrinsic preferences*.

I examined differences in justification codes based on whether the response was to endorse the Ability Informant or to endorse the Effort Informant. When children endorsed the Effort Informant, 40% of responses were uninformative. Of informative responses, 28% referenced *effort*, 24% referenced *ability*, 24% referenced *physical attributes*, 0% referenced *personality traits*, 0% referenced *occupation*, and 24% referenced *intrinsic preferences*. When children endorsed the Ability Informant, 33% of responses were uninformative. Of informative responses, 0% referenced *effort*, 98% referenced *ability*, 2% referenced *physical attributes*, 0% referenced *personality traits*, 0% referenced *occupation*, and 0% referenced *intrinsic preferences*.

Significantly more participants referenced *effort* in their justifications after endorsing the Effort Informant as the scientist they would prefer to ask future question to than the Ability Informant ($z = -3.70$, $p < 0.001$). Significantly more participants referenced *ability* in their justifications after endorsing the Ability Informant as the scientist they would prefer to ask future question to than the Effort Informant ($z = 6.49$, $p < 0.001$). Additionally, significantly more participants referenced *physical attributes* and *intrinsic preferences* in their justifications after endorsing the Effort Informant as the scientist they would prefer to ask future question to than the Ability Informant ($zphysical = -2.87$, $p < 0.01$; $zpreference = -3.40$, $p < 0.001$).

Which scientist is more like you? Using the coding scheme detailed in the Method, children's responses to the justification question were coded. There was a total of 104 justifications. Of these, 35% were *uninformative*, leaving 68 informative responses. Of the informative responses, 38% referenced *effort*, 38% referenced *ability*, 20% referenced *physical attributes*, 1% referenced *personality traits*, 0% referenced *occupation*, 3% referenced *intrinsic preferences*.

I then explored differences in justification codes based on whether the response was to endorse the Ability Informant or to endorse the Effort Informant. When children endorsed the Effort Informant, 29% of responses were uninformative. Of informative responses, 71% referenced *effort*, 9% referenced *ability*, 18% referenced *physical attributes*, 0% referenced *personality traits*, 0% referenced *occupation*, and 3% referenced *intrinsic preferences*. When children endorsed the Ability Informant, 33% of responses were uninformative. Of informative responses, 6% referenced *effort*, 68% referenced *ability*, 24% referenced *physical attributes*, 3% referenced *personality traits*, 0% referenced *occupation*, and 0% referenced *intrinsic preferences*. Significantly more participants referenced *effort* in their justifications after endorsing the Effort Informant than the Ability Informant ($z = -5.49$, $p < 0.001$). Additionally, significantly more participants referenced *ability* in their justifications after endorsing the Ability Informant as being more like them than the Effort Informant ($z = 4.99$, $p < 0.001$).

Mindset Question

For children's responses to the Mindset Question, I found that significantly more children endorsed a growth mindset than endorsed a fixed mindset (80% compared to 20%; $z = 8.27$; $p < 0.001$). I also found that children's mindset did not predict either their responses on the Object Label Endorsements or Science Question Ask Trials ($\beta label$ =

0.02, $SE = 0.34$, $p > 0.05$; $\beta question = 0.51$, $SE = 0.27$, $p = 0.06$)

Coding Mindset Question Justifications

Children were asked to justify their responses to the Mindset Question. Justifications were then coded according to the mindset question coding scheme detailed in the Method. There was a total of 124 justifications. Of these, 26% were *uninformative*, leaving 92 informative codes. Of informative responses, 58% referenced *learning*, 11% referenced *stability of intelligence*, and 32% referenced *personal connections and examples*.

I further explored whether there were differences in justifications based on expressed mindset. Of children who endorsed a growth mindset, 64% of justifications referenced *learning*, 5% of justifications referenced *stability of intelligence*, and 31% referenced *personal connections*. Of children who endorsed a fixed mindset, 9% of justifications referenced *learning*, 55% referenced *stability of intelligence*, and 36% referenced *personal connections*. I found a significant relationship between children's mindset and their references to either *learning* or *stability of intelligence*, with children who endorsed a growth mindset more likely to reference *learning* and children with a fixed mindset more likely to reference *stability of intelligence*.

Science Question Ask Trial Endorsement Profiles

In order to make sense of how children's responses to the Selective Trust Questions related to their responses to the Explicit Judgment Questions and Mindset Question, I gave children a profile based on their scores (from 0 to 4) on the Science Question Selective Trust Endorsements. Children who scored a 0 or 1 were labeled as

Effort-Oriented; children who scored a 3 or 4 were labeled as Ability-Oriented; and children who scored a 2 were labeled as Neutral. I chose to create the profiles based on the Science Question Ask Trials and not the Object Label Endorsements because as a group, children had a clear preference for one informant over the other for the Science Question Ask Trials but not the Object Label Endorsements. I found that 53% of children had a Neutral profile ($N = 53$), 35% were Ability-Oriented ($N = 35$), and 12% were Effort-Oriented ($N = 12$).

I then examined children's justifications to the ask trials to see if justifications referencing *ability* and *effort* differed by profile. 33% of codes were uninformative and thus excluded from these analyses, leaving 286 informative justifications. Of these, informative justifications, 68% of references to *effort* were produced by Neutral children, 11% were produced by Ability-Oriented children, and 21% were produced by Effort-Oriented children. 41% of references to *ability* were produced by Neutral children, 51% were produced by Ability-Oriented children, and 8% were produced by Effort-Oriented children (see Figure 3.1). Neutral children were significantly more likely to reference *effort* than *ability* in their justifications ($z = 3.34$, $p < 0.001$). Ability-Oriented children were significantly more likely to reference *ability* than *effort* in their justifications ($z = -4.98$, $p < 0.001$). Effort-Oriented children were significantly more likely to reference *effort* than *ability* in their justifications ($z = 2.52$, $p < 0.01$).

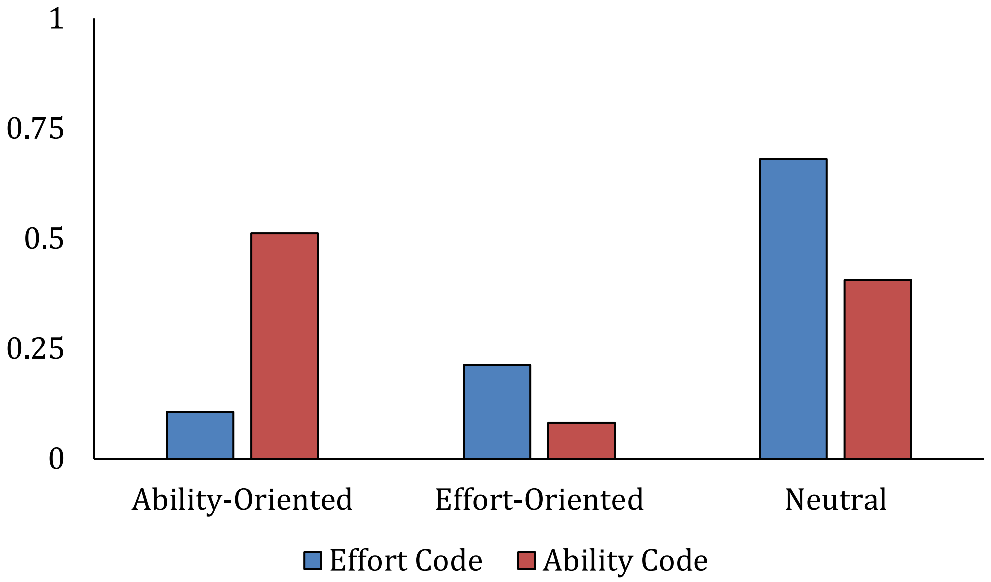

Figure 3.1. Proportion of children's justifications referencing effort and ability by profile.

Next, I turned to the Explicit Judgment Questions by profile: which scientist won an award, which scientist children would want to ask science questions to in the future, and which scientist was more like the child. Then, I examined children's responses to the Mindset Question by profile.

Which Scientist Won an Award?

I compared children's informant preference based on their profile. Results indicated that there were significant differences in children's informant preferences based on profile (Fisher's exact, $p < 0.05$; see Figure 3.2). I then looked at each profile individually to analyze specific within-profile differences. Neutral children showed no informant preference when asked which scientist had won an award ($z = -0.62$, $p > 0.05$). Ability-Oriented children were more likely to endorse the Ability Informant as having won an award ($z = 3.18$, $p < 0.01$). Effort-Oriented children showed no preference when choosing which informant had won an award ($\chi 2 = 1.33$, $p > 0.05$).

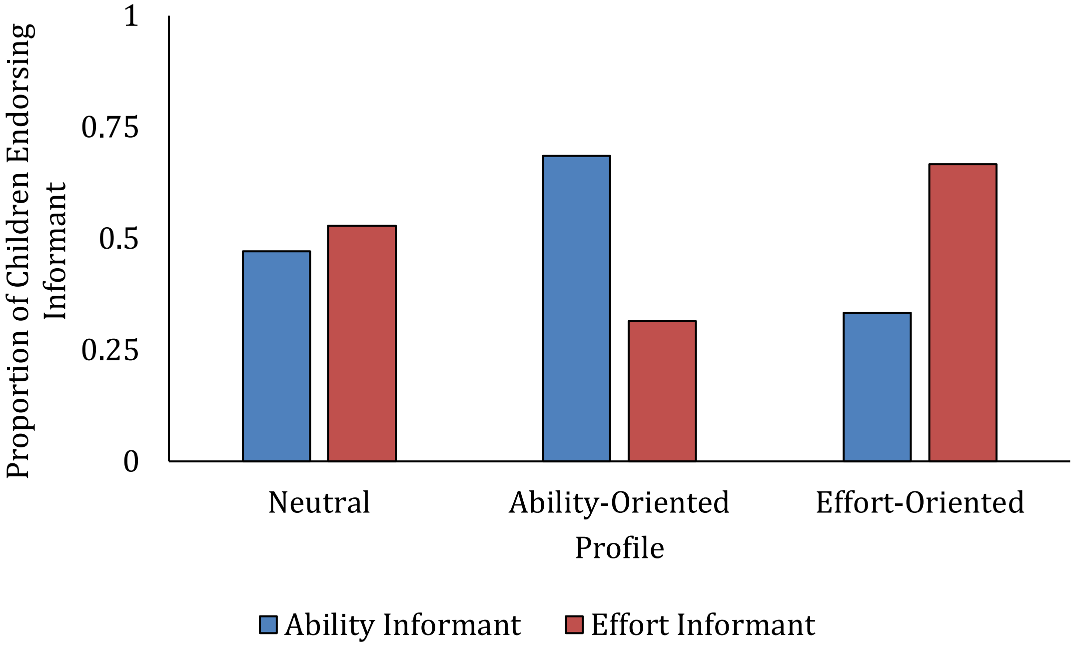

Figure 3.2. Percentage of children endorsing the Ability or Effort Informant by profile for explicit judgment question 1: Which scientist won an award?

Which Scientist Would You Ask Questions?

I compared children's informant preference based on their profile. Results indicated that there were significant differences in children's informant preferences based on profile (Fisher's exact, $p < 0.001$; see Figure 3.3). I then looked at each profile individually to analyze specific within-profile differences. Neutral children showed a preference for the Ability Informant for this question ($z = 2.47$, $p < 0.05$). Ability-Oriented children were more likely to endorse the Ability Informant for this question ($z = 7.48$, $p < 0.001$). Effort-Oriented children were more likely to say that they would ask the Effort Informant another science question ($\chi 2 = 8.33$, $p < 0.01$).

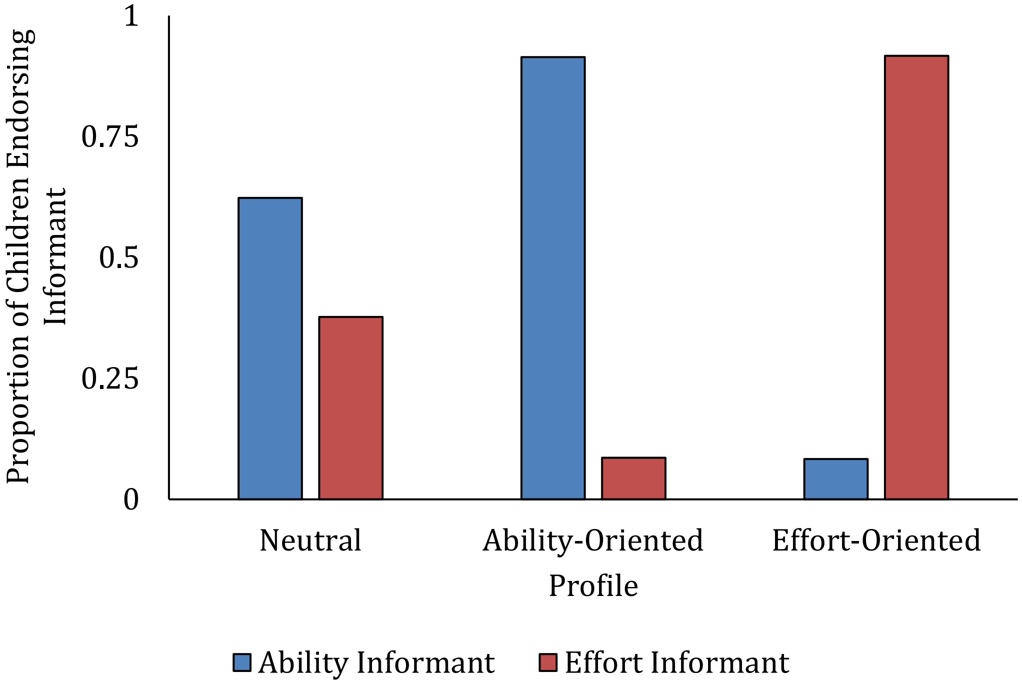

Figure 3.3. Percentage of children endorsing the Ability or Effort Informant by profile for explicit judgment question 4: Which scientist would you ask a question?

Which Scientist Is More Like You?

I compared children's informant preference based on their profile. Results indicated that there were significant differences in children's informant preferences based on profile (Fisher's exact, $p < 0.05$; see Figure 3.4). Neutral children showed a preference for the Ability Informant for this question ($z = 2.68$, $p < 0.01$). Ability-Oriented children were equally as likely to endorse the Ability Informant as the Effort Informant ($z = -0.49$, $p > 0.05$). Effort-Oriented children were more likely to prefer the Effort Informant ($\chi 2 = 5.33$, $p < 0.05$).

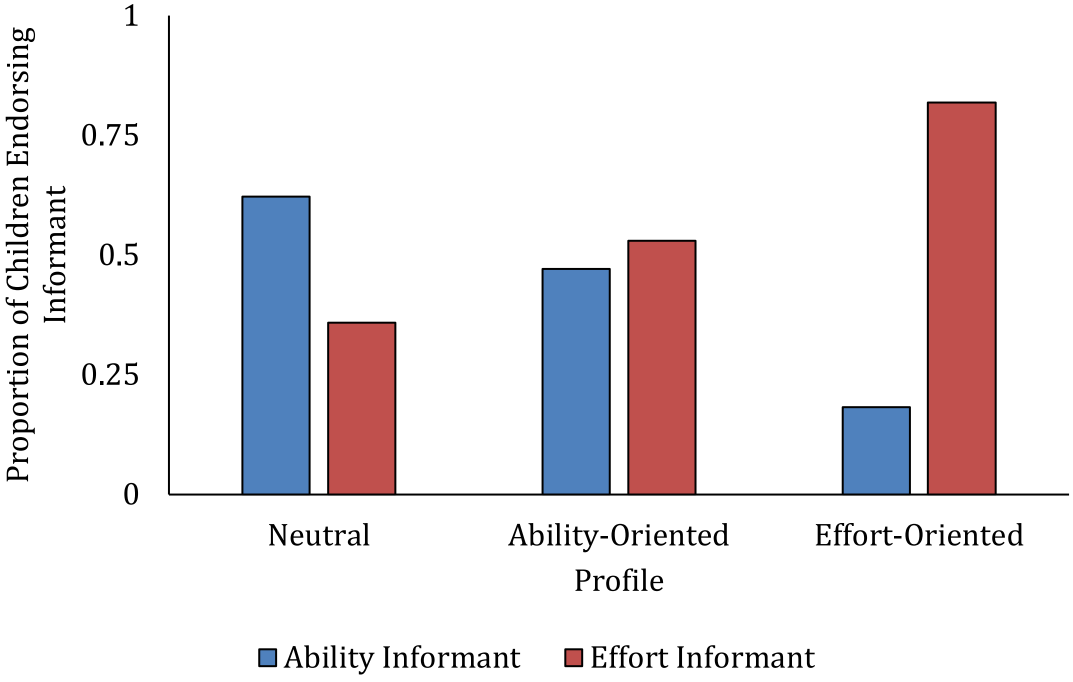

Figure 3.4. Percentage of children endorsing the Ability or Effort Informant by profile for explicit judgment question 5: Which scientist is more like you?

Mindset Question and Profile

I explored whether children's mindset and assigned profile related and found that there were significant differences in children's mindset based on profile (Fisher's exact, $p < 0.05$; see Figure 3.5). Children with fixed mindset and children with growth mindset were equally likely to have a Neutral profile ($z = -0.62$, $p > 0.05$). Children with growth mindset were more likely to be Ability-Oriented than children with fixed mindset ($z = 2.03$, $p < 0.05$). Children with fixed mindset were more likely to be Effort-Oriented than children with growth mindset ($z = -2.01$, $p < 0.05$).

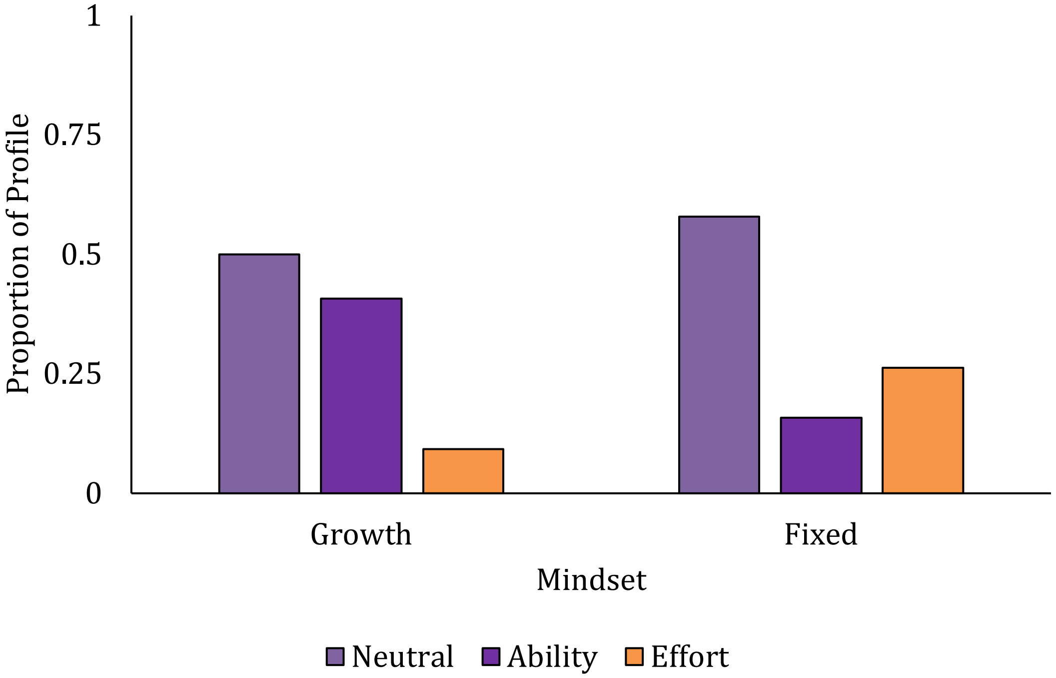

Figure 3.5. Proportion of children who fall into each profile based on mindset endorsement.

Persistence Task

For our final set of analyses, I examined whether children's persistence on a science game differed based on condition (whether they were re-introduced to the Ability Informant or Effort Informant before playing the game). Following prior work (Rhodes et al., 2019), I conducted a Cox regression survival analysis to estimate the probability of children choosing to stop the game after a certain 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 stop playing the game. I tested for whether Condition, Child Gender, Child Age, and Task Accuracy predicted Persistence on the task. Analyses indicated that children's persistence did not differ by Condition, Child Gender, Child Age, or Task

Accuracy ($\beta condition$ = -0.13, SE = 0.25, p = 0.61; $\beta gender$ = -0.05, SE = 0.26, p = 0.84; βage = -0.06, SE = 0.10, p = 0.54; $\beta accuracy$ = -0.91, SE = 0.50, p = 0.07).

Discussion

Interpreting Selective Trust Responses

Findings indicated that there were no age or gender-related differences on the Object Label endorsements or Science Question Ask trials. Based on prior work, it had seemed possible that there could be gender-related differences in children's responses, with boys more likely to prefer the Ability Informant. This prediction was based on the finding that six-year-old girls, but not boys, have been shown to prefer a game for children who are hardworking rather than smart. However, deciding who would be the most trustworthy person to learn from is different from deciding what kind of game to play. The mechanisms involved in each situation may be different. In the latter case, children may have focused on their perceptions of themselves and their own abilities, whereas in the former case they may focus on who will provide them with the most useful, accurate information. The lack of age-related differences in children's informant preferences appears to support recent work from Ma et al. (2022) which shows a developmental shift in preference for brilliant individuals from childhood to adulthood, with four- to seven-year-old children showing a stronger preference for naturally brilliant people. This finding suggests that the developmental shift occurs later in development, perhaps in middle childhood or adolescence.

Why did children show a preference for the Ability Informant over the Effort Informant when choosing who they would prefer to ask a science question? On the ask trials, findings indicated that significantly more participants referenced *effort* after endorsing the Effort Informant than after endorsing the Ability Informant. By contrast, significantly more references to *ability* were made when participants had endorsed the Ability Informant. Thus, when children indicated the Ability Informant, they appear to have viewed the informant as smarter and more knowledgeable about science than the Effort Informant. Some work has shown that four- to five-year-old children's understanding of competence is being constructed (Leonard et al., 2019). At this age, children are able to infer others' competence based on task efficiency and quality of an outcome (Leonard et al., 2019). Children may have viewed the Ability Informant, who was described as doing "experiments that always worked the first time she tried them" as more efficient, more competent, and therefore better to ask science questions than the Effort Informant, who was described as having to "try many different experiments before one worked." In this study, children may have valued task efficiency more highly than quality of an outcome, as both scientists were described as achieving the highest grades on their science tests.

This finding also aligns with research showing that children are affected by the "myth of brilliance" attributed to scientists and think that a more brilliant scientist would be better able to answer their science questions (Leslie et al., 2015). Recent work has explored how Chinese 4- to 7-year-old children and adults perceive "naturals" (individuals with natural ability) and "strivers" (individuals who work hard) in the domain of interpersonal relationships (i.e., individuals who are good at networking or making friends; Ma et al., 2022). They found that adults and children viewed "naturals" as more competent. Children also found “naturals” to be warmer than “strivers,” suggesting a broader preference for the “natural” that fades over development. This work also found a further developmental trend whereby young children preferred to socialize with and allocate resources to “naturals” over “strivers,” but adults preferred “strivers” over “naturals” in these cases (Ma et al., 2022). These findings align with our findings that children preferred the Ability Informant (who might be termed a natural) over the Effort Informant (a striver). Future work might consider whether children’s preference could involve not only a belief that the Ability Informant was smarter but also by a general belief that the Ability Informant was warmer and a better friend option than the Effort Informant.

Why might young children show an overall preference for a scientist described as smart over a scientist described as hardworking when deciding from whom to ask a science question but not when choosing from whom to learn the label of an object? There are multiple plausible possibilities. First, although the scientists are described as equally successful, children may view the smart informant as more accurate or competent; prior work indicates that children prefer accurate informants over inaccurate informants, potentially explaining this difference (e.g., Johnston et al., 2015). It is also possible that children view ‘smartness’ as an innate characteristic, regardless of domain. For example, a hardworking individual might know a large amount about a specific domain, but less about a different one, whereas a smart individual might be proficient across multiple topics. These explanations do not take into account the fact that this ‘smart’ scientist preference occurs when children are deciding from whom to ask question but not when deciding from whom to learn a novel word. One possibility for this domain difference is that knowing a word and having the expertise to provide a scientific explanation require different skillsets. Prior work indicates that young children take expertise into account when determining who to trust in a situation (Clegg et al., 2019; Sobel & Corriveau, 2010). For example, a child might expect that many adults would know the label for an object but that only certain adults would know how or why a scientific phenomenon occurs.

Interpreting Explicit Judgment Responses

Findings supported the idea that children were able to track which informant was the Ability Informant and which was the Effort Informant, suggesting that their responses to the selective trust and explicit judgment questions focused on an understanding that one informant was smart and the other was hardworking.

Findings also indicate that children were more likely to ask the Ability Informant than the Effort Informant a further science question. Justification coding indicated that children referenced the scientist's ability and intelligence as a primary reason for why they chose a particular informant and were more likely to reference ability and intelligence after selecting the Ability Informant. Similar to the ask trials, children may have viewed the Ability Informant as better equipped and having a higher level of expertise in the domain of science than the Effort Informant.

There were no differences in children's judgment of which informant would win a science award. This finding may indicate that children view effort and ability as equally viable paths to long-term success, even if in the short-term (e.g., when in want of an immediate response) they view the Ability Informant as a more helpful source of information. Additionally, children were equally likely to say that the Ability Informant and the Effort Informant was ‘like them.’ Children’s justifications were equally likely to mention ability as to mention effort. This finding may indicate that an equal proportion of children view themselves smart as view themselves hardworking. Indeed, an equal proportion of children referenced effort as referenced ability in their justifications of why they viewed themselves as similar to one informant or another. However, it is worth noting that 20% of responses for this question referenced physical attributes, perhaps indicating that children interpreted the question as asking them to compare themselves physically to the two scientists.

Interpreting Mindset Question Responses

Children were significantly more likely to endorse a growth mindset than a fixed mindset and mindset was not a predictor of children’s responses to the selective trust questions, despite predictions that it might be. Some work has found that 70% of 15-year-old students in the United States endorse a growth mindset (PISA, 2018). This work shows that by adolescence, the chances of a student endorsing a growth mindset are high. Although the importance of cultivating growth mindset has been established in adolescence and adulthood (e.g., Blackwell et al., 2007; Yeager et al., 2019), less work has systematically explored mindset in early childhood. Nevertheless, emerging research has resulted in the creation of a new mindset measure for young children (Gunderson et al., 2013; Muradoglu et al., under review; Ruzek et al., 2020). Other work suggests that a culture of school growth mindset, or the belief of teachers that they can help all students learn, is higher for elementary schools than high schools (Hanson et al., 2016). Additionally, some work has shown that three- to five-year-old children's growth mindset, as measured by willingness to participate, is high. Thus, the finding that the majority of young children in this study endorsed a growth mindset aligns with and adds to prior work.

Justifications for why children endorsed a specific mindset were revealing and present a new way of understanding children's perceptions of a growth or fixed mindset. Children endorsing a growth mindset were more likely than children with a fixed mindset to provide justifications that referenced learning, whereas children with a fixed mindset were more likely to justify their response by referencing the stability of intelligence. This finding suggests that children with a growth mindset viewed learning as a primary reason that intelligence is able to increase over time rather than remaining fixed. Additionally, children frequently mentioned personal connections or examples to illustrate their justifications, showing that they were connecting the development of intelligence with their own lives and experiences. Anecdotally, many children referenced school when discussing personal connections, indicating that attending school may be viewed as a means to increase intelligence.

Interpreting Profile Data

To explore how children's responses to the ask trials questions related to the explicit judgment questions and mindset question, I sorted children into one of three profiles, Neutral, Effort-Oriented, or Ability-Oriented, based on their selective trust responses. Children who scored a 0 or 1 were labeled as Effort-Oriented; children who scored a 3 or 4 were labeled as Ability-Oriented; and children who scored a 2 were labeled as Neutral. Overall, most children fell into the Neutral category, meaning that they chose at random or did not have a strong preference for either the Effort or Ability Informant. The profiles were an exploratory way to understand children's responses to the explicit judgment questions and mindset questions. I discuss limitations of these profiles in the Limitations section. I examined children's justifications by profile and found that Neutral children were more likely to reference effort than ability across their justification responses for why they had chosen the informant they chose. Thus, it appeared that even when children endorsed the informants at random, placing no more or less weight on informant ability or effort, they had a preference for justifying their responses with explanations related to hard work and effort. Effort-Oriented children were also more likely to reference effort than ability in their justifications; by contrast, Ability-Oriented children were more likely to reference ability than effort in their justifications.

Although I had no concrete predictions about how profile would relate to explicit judgments, I anticipated that Ability-Oriented children would prefer the Ability Informant whereas Effort-Oriented children would prefer the Effort Informant and Neutral Children would show no informant preference.

For the question about which scientist would win an award, Neutral and Effort-Oriented children displayed no preference for either informant, whereas Ability-Oriented children were more likely to endorse the Ability Informant as having won an award. This finding suggests an effect of profile, whereby children who showed a preference for the

Ability informant were more likely to endorse the idea that that informant would receive accolades.

Similarly, when asked which scientist they would ask further science questions, children showed significant differences based on profile. Here, Ability-Oriented and Neutral children were more likely to endorse the Ability Informant whereas Effort-Oriented children were more likely to endorse the Effort Informant. This finding suggests that children are more likely to turn to a scientist who displays no challenges towards achievement unless they had previously showed a preference for a hardworking scientist.

When asked which scientist was more ‘like them,’ children also showed significant differences in informant preference by profile. In this case, Neutral children but not Ability-Oriented children showed a preference for the Ability Informant, whereas Effort-Oriented children were more likely to say that they were more similar to the Effort Informant. It is unclear why Ability-Oriented children did not view themselves as more similar to the Ability Informant. Prior work exploring children’s sense of belonging in STEM suggests that one mechanism by which children make STEM-related decisions is to engage in a social comparison between themselves and scientists (Rhodes et al., 2019). It seems possible that in this case, Ability-Oriented children may have compared themselves to the Ability Informant and then thought that, by comparison, they were not so smart. It is also possible that this question was not clear to children or that, as discussed in the Limitations section, the profiles may not fully capture children’s preferences.

I also examined children’s profiles based on mindset. Contrary to expectations, children who endorsed a growth mindset were more likely to be Ability-Oriented than children who endorsed a fixed mindset. Children who endorsed a fixed mindset were more likely to be Effort-Oriented than children who endorsed a growth mindset. Additionally, children with a growth mindset were more likely to be Ability-Oriented than Effort-Oriented whereas no such difference existed for children with a fixed mindset. It is possible that children with a growth mindset were more likely than children with a fixed mindset to strategize about which informant would provide them with the highest quality information, thereby allowing them to learn more and grow smarter. It is also possible that children with a fixed mindset believed that it is not possible "to get smarter and smarter all the time," however, they may very well believe that it is possible to work hard in order to learn something new. In other words, children who professed a fixed mindset may have viewed learning or acquiring knowledge as separate from intelligence. Children with a fixed mindset viewed smartness as a fixed trait but viewing smartness as a fixed trait does not preclude the belief that people can learn through other avenues. Thus, these fixed mindset children may have viewed hard work as a critical component of success, explaining why they were Effort-Oriented.

Growth mindset has been shown as a perspective on intelligence that can boost adolescents' success in school (e.g., Blackwell et al., 2007; PISA, 2018). However, there is currently debate about the extent to which growth mindset interventions are effective (see McNamara& Burgoyne, 2022 in conversation with Tipton et al., 2022). Additionally, it is important to keep two things in mind regarding mindset. First, fixed versus growth mindset is a false dichotomy. It is entirely possible to hold some beliefs about intelligence that might endorse a fixed mindset and some that endorse a growth mindset. Mindset may exist more on a spectrum than is discussed in the literature. Second, mindset and its impacts on children's beliefs and behaviors in early childhood, especially in the domain of STEM, has not been extensively studied. Accordingly, in early childhood, theories of intelligence may not be constructed in the same way as in adolescence and adulthood. For example, a young child might believe that people are born with a certain amount of intelligence but may also believe that hard work is an important element of success. Future research is needed to understand exactly how theories of intelligence are constructed, maintained, and expressed across the lifespan.

Interpreting Persistence Task Findings

I expected to find that children had persisted longer at a science task when introduced to the task by a hardworking scientist rather than to a smart scientist. However, children's persistence did not differ by condition. In other work using a similar task, condition similarly did not impact children's persistence, with the hypothesis that the intervention was too brief to have an impact on explicit behavior (Kumar et al., 2023). It seems that a similar reason could be that the brief reintroduction of the smart or hardworking scientist was not enough to change children's behavior.

Limitations and Future Directions

I note several limitations to this work. First, participants were recruited by Facebook and tested on Zoom. This may have led to selection bias wherein families who use Facebook to find activities for young children, and specifically STEM activities, would be more likely to participate than families who do not, potentially leading to a sample of participants who have more exposure to science and science games than average (Su & Ceci, 2021). Additionally, data were collected over Zoom and therefore the sample was limited to children whose families have access to computers and a strong Wi-Fi connection at home. There is evidence of a digital divide, whereby people living in poverty, from low-income backgrounds, and from non-metropolitan areas have less access to internet services than people from other socioeconomic statuses (SES; Swenson & Ghertner, 2020). Although the vast majority of children (95%) in the United States have access to the internet, there have been shown to be differences in the frequency of availability and quality of internet by SES, with families from lower SES backgrounds having fewer devices available for internet use than families from higher SES backgrounds (NCES, 2021). Data collection over Zoom has become a norm within the field of social cognitive development since the advent of the COVID-19 pandemic prevented researchers from either inviting families into a lab space to participate in research or going into local schools for data collection. Several limitations and concerns surrounding Zoom data collection have emerged, such as the Zoom fatigue phenomenon (e.g., Wiederhold et al., 2020), limited non-verbal communication (such as the inability of children to point to their preferred response), and the lack of a controlled research environment (Su & Ceci, 2021; Bambha & Casasola, 2021).

Additionally, most participants in this study were White, middle to upper middle class, and highly educated. Thus, findings are not generalizable beyond this demographic (Henrich et al., 2010). Indeed, prior selective trust studies have found cross-cultural differences in children's informant preferences (e.g., Chen, 2012). Additionally, families from non-WEIRD populations may express different messages to their children about intelligence and hard work than families from WEIRD populations. For example, for children in many non-WEIRD cultures, there is an emphasis on learning by observation rather than through question-asking (Rogoff et al., 2003). Thus, learning and perceptions of what it means to be smart or a hard worker may be viewed very differently in these cultures. Future work should explore socioeconomic and cultural differences in young children's selective trust of smart and hardworking informants.

One limitation of this work is the forced choice paradigm. In real life, children would rarely need to choose between two informants who differ so fundamentally and explicitly. Nevertheless, this paper provides important insight into how children use information about effort and ability to weigh from whom to trust and indicates that there is a great deal of nuance in children's decision-making. For example, how do children view teachers as sources of information? Are they viewed more as brilliant or as effortful? And how does this impact the types and quantity of questions children ask? Additionally, are there domain differences in children's decision-making when deciding which teacher to ask for information? One could imagine that a child would ask the science teacher a science question over a language arts teacher. But could there also be gender differences in who children want to ask (e.g., preferring to ask a male teacher over a female teacher)?

Another important limitation was that the profiles as constructed are a potential limitation as I do not know how stable or informative these profiles are. For example, a child who is Ability-Oriented (selecting primarily the Ability Informant) one day could be Neutral or Effort-Oriented the next. Future work could explore children’s profile over multiple time points and could further explore how and whether these profiles relate to children’s school performance and motivation.

A final limitation, and a possible future direction, emerges from the fact that the informants in this study are both White women. A recent study has found that when the experimenter was a male, girls were more likely to endorse male informants over female informants regarding scientific testimony (Rackoff et al., 2022). It would be interesting to explore whether children would respond differently to smart versus hardworking scientists who varied by race and gender, especially considering research showing that children view intelligence differently depending on race and gender (e.g., they view Black women as more brilliant than Black men, Jaxon et al., 2019). For example, one could imagine that children might selectively trust a smart White man over a hardworking Black man, but, due to a bias for viewing White men as intelligent, might not show a strong preference for a smart Black man compared to a hardworking White man.

Conclusion

Taken together, this study uses experimental methodology to examine how malleable factors like adults’ language impact children’s motivation and persistence in STEM. Much of the literature on STEM learning and reducing the achievement gap in STEM focuses on older children, high school students, and college students (e.g., Cheryan et al., 2009; Blackwell et al., 2007). This paper focuses on early childhood, including the preschool and early elementary years, as a valuable period of development to study because during this time in particular children rely heavily on adult information (especially from teachers) to understand the world around them. For example, this work adds to research showing that even in early childhood children are selective about from whom to learn (Harris et al., 2018). Thus, research-based interventions in early childhood that emphasize use of language shown to enhance STEM motivation for children are critical to increasing participation of underrepresented groups in STEM.

Relatedly, results from this work have clear applications to educational contexts, paving the way for future research on classroom interventions aimed at increasing participation of underrepresented groups in STEM across development. For example, results from this work may suggest that a small shift in language on the part of educators from highlighting success to emphasizing the process of science, including mistakes and failures, could boost children's motivation in STEM.

CHAPTER FOUR

Paper 3: How linguistic and visual cues presented in a science storybook impact children’s persistence and sense of belonging in STEM

Introduction

How can adults cushion the impact of negative stereotypes related to STEM on children’s (and especially girls’) self-perceptions, interest, choices, and behavior related to STEM? One method is through avoiding generic statements about social categories, which convey societal expectations about social groups (e.g., Cimpian, 2010; Foster-Hanson et al., 2016; Gelman et al., 2004; Rhodes et al., 2018; Wodak et al., 2015; Prasada, 2000). For example, adults’ use of generic (as opposed to specific) impacts children’s performance and motivation (e.g., Cimpian, 2010). Young children exposed to generic praise (“You are a good drawer”) were more likely to avoid drawing after being criticized than children exposed to specific praise (“You did a good job drawing;” Cimpian et al., 2007). A second method is through using action-based language over identity-based language. Five- to seven-year-old girls’, but not boys’, persistence on a science task was enhanced when exposed to “action-based” language (e.g., “Let’s do science”) than when exposed to “identity-based” language (e.g., “Let’s be scientists”; Rhodes et al., 2019; Rhodes et al., 2020). Similarly, the use of scientific identity-based language, but not action-based language, negatively impacts children’s science interest and self-efficacy (Lei et al., 2019). Taken together, the mechanism underlying the effects of “identity-based” language is closely aligned with the mechanism underlying the effects of generic language. Both language types highlight that members of a certain group (in this case “scientists”) share fundamental properties and might not be inclusive of all social groups (Lei et al., 2019).

One reason children – and especially girls – may be impacted by subtle differences in how a science activity is presented is because they may lack a sense of belonging in STEM. Indeed, merely belonging to a task-relevant social group can increase motivation and persistence on a task (Master et al., 2017). In the current study, I explore how reading a storybook could enhance young children’s sense of belonging in STEM, resulting in an increase in their persistence, interest, and self-efficacy in STEM. Before turning to the study methodology, I briefly review relevant literature on belonging in STEM and the use of storybooks in promoting children’s science learning.

Sense of Belonging in STEM

From a young age, children are aware that they belong to certain social groups, including racial, gender, and ethnic groups (e.g., Kinzler et al., 2010; Maccoby, 1988; Shutts et al., 2013). The domain of STEM is particularly interesting to explore with respect to how social group membership impacts young children’s beliefs and behaviors, because the category “scientists” is a highly homogeneous social group composed primarily of white males (Master & Meltzoff, 2020; NSF, 2023). Scientists are also a highly stereotyped group (Cheryan et al., 2009; 2017). Whereas men in STEM are stereotyped as brilliant or geniuses, women are stereotyped as not naturally gifted in certain areas of STEM (Chestnut et al., 2018). Although certain science fields have shifted toward gender balance, specific fields including physics, engineering, chemistry, and computer science remain imbalanced, with far more males than females pursuing degrees and careers (Cheryan et al., 2015; NSF, 2023). Some research suggests that cultural stereotypes about the types of people who belong in those fields (typically "nerdy," socially isolated males) are the primary mechanism for making girls feel a lack of belonging in STEM fields (Cheryan et al., 2015).

In early childhood, children make a distinction between beliefs about interest in STEM and STEM ability. For example, although children endorse beliefs that boys have a greater interest in STEM by age six, it is not until middle to late childhood that they endorse beliefs that boys have a greater ability in STEM than girls (Cvencek et al., 2011; Martinot & Désert, 2007; Passolunghi et al., 2014). This dichotomy between beliefs about interest and ability suggests that one way to promote gender inclusivity in STEM is to minoritized children's (including girls and non-White children) interest in STEM. Much of the prior work in this area has focused on increasing older girls' and adults' interest in STEM (e.g., through exposure to non-stereotypical role models; Cheryan et al., 2011; Master et al., 2016); however, a growing body of research has explored ways to increase interest in STEM in early childhood. For example, six-year-old girls who endorse negative stereotypes about women in STEM (and more favorable stereotypes about men in STEM) express less interest and a lower sense of belonging in STEM fields (Master et al., 2021). However, hands-on experience is related to enhanced feelings of belonging: young girls who report strong stereotypes about and low interest in computer science report greater interest and feelings of self-efficacy in the area after gaining programming experience (Master et al., 2017).

Endorsements of stereotypical beliefs about STEM (i.e., beliefs that boys are brilliant in STEM; Chestnut et al., 2018) also impact young children's beliefs and choices related to themselves. For example, 6-year-old children who believed that their gender group was 'bad at math' rated their own math ability as lower than did children who believed their gender was good at math (Master et al., 2021). Similarly, when given a choice between two games, young girls choose to play a game for children who are hardworking over a game for children who are smart (Bian et al., 2018; Bian et al., 2017). Such findings highlight relations between gender stereotypes and self-perception: many children view gender as a strong aspect of their identity at this age (Rogers & Meltzoff, 2017) and as such, begin to link gender stereotypes (e.g., "Girls are bad at math") to their self-perception (e.g., "I am a girl, so I am bad at math"; Patterson & Bigler, 2010). Taken together, young girls' lack of interest in STEM may lead to downstream effects on the amount of representation of women in STEM.

The Current Study

In the current paper, I explore two factors that may enhance young learners' STEM interest and persistence: the language and character diversity in a science storybook. In addition, I examine relations between children's perceptions of themselves (including their mindset, their self-evaluation of whether they are smart or hardworking, and the importance of their gender) and the type of science storybook they read. Previous research has indicated storybook reading as a method for increasing children's persistence and performance in the domain of science (Emmons et al., 2018; Kumar, Haber et al., 2021; Leech et al., 2020; Leech et al., 2019).

In Study 1a, five- to seven-year-old children were exposed to a science storybook that feature all White, all male characters. The storybooks differed based on language type, with half of children reading a storybook that utilized action-based language and half of children reading a storybook that utilized identity-based language. In Study 1b, I examined whether and how a storybook featuring diverse characters might relate to children's persistence on a science task and science interest. In this study, children were exposed to the same science storybook as in Study 1a, except that instead of including White, male characters, the storybook was populated with racially and gender diverse characters. Again, half of children received a storybook that utilized action-based language and half of children received a storybook that utilized identity-based language.

Predicted Results

In making predictions, I first considered the potential effects of language in Study 1a and Study 1b. The findings surrounding children's responsiveness to action-based and identity-based language are mixed. Although some research in the United States has indicated that five- to seven-year-old girls, but not boys, persist longer at a science task after hearing action-based language (Rhodes et al., 2019), some research from Ireland has shown no difference in persistence based on language (Gilligan et al., 2023). Moreover, other research has found that boys persisted longer than girls on a science persistence task regardless of linguistic or visual input (Gilligan et al., 2023; Kumar et al., 2023). Thus, I had no strong predictions about potential gender differences in children's persistence by language condition. Similarly, some recent research on children's science interest and feelings of self-efficacy indicates that six- to eleven-year-old children display enhanced science interest and self-efficacy following hearing action-based rather than identity-based language, with no associated gender differences (Lei et al., 2019). Accordingly, I predicted that all children would likely express greater feelings of science interest and self-efficacy in the action-based rather than identity-based conditions.

In addition to considering the effects of language, I also considered how the character diversity in the science storybook might impact children's science interest, feelings of self-efficacy, and persistence. To the best of my knowledge, little work in social cognitive development has specifically explored how the race and gender of storybook characters influences science interest and persistence in early childhood. Nevertheless, some research indicates that exposing third-grade students to nonfiction storybooks about scientists that included vivid pictures throughout led children to develop a broader perception of a typical scientist (Farland, 2006). In addition, qualitative research with first-grade students has shown that exposure to scientists from diverse sociocultural backgrounds led students to broaden their perceptions of scientists as a group and recognize that scientists conduct cognitive work in addition to hands-on experiments (Sharkawy, 2012). Similarly, work with six- to- eight-year-old girls suggests that presenting stories about women in science can be a way to counteract negative stereotypes about girls in STEM (Buckley et al., 2022). Thus, I anticipated that children might persist longer at a science task and express greater feelings of science interest and self-efficacy when exposed to a diverse group of scientists (Study 1b) than when exposed to a homogeneous group of all-male, White scientists (Study 1a).

In addition to science interest, self-efficacy, and persistence, I also explored children's views of a group of scientists as smart or hardworking (Group Trait

Attribution), children's evaluation of themselves as smart or hardworking (Self-Evaluation), children's mindset (fixed or growth), and children's evaluation of the importance of their gender (Gender Importance). Some of my prior work has indicated that children evaluate scientists differently depending on the group composition (Kumar et al., 2022). Therefore, I predicted that children would evaluate scientists described in terms of action-based language as more hardworking and scientists described in terms of identity-based language as more smart. Based on this work, I also anticipated that children would view characters in a diverse group (Study 1b) as smart but characters in a more homogeneous group (Study 1a) as hardworking. Mindset has been shown to be a malleable trait in childhood (e.g., Law et al., 2021). Therefore, I predicted that children's might be more likely to endorse a growth mindset after reading the action-based storybook than the identity-based storybook due to the promotion of the idea that intelligence is fluid. I also anticipated that more children would endorse a growth mindset in Study 1b (diverse characters), as compared to Study 1a (homogeneous characters).

The questions regarding children's self-evaluation and gender importance were more exploratory in nature, and thus I did not have strong predictions about their impact on language type or character diversity. Some research has indicated that six-year-old girls prefer to play a game for hardworking children rather than smart children (Bian, 2017). Based on these findings, I anticipated that children's perceptions of themselves as smart or hardworking might be malleable in the face of varied language and character diversity.

Prior research has indicated that gender is a salient social category for children as early as age 3 (e.g., Rogers & Meltzoff, 2017; Shutts et al., 2013). Other research has indicated that gender is strongly related to identity (e.g., stronger than racial identity) and is a category that children recognize as being divisive (Rogers & Meltzoff, 2017). Based on these data, I anticipated that viewing gender as a more important characteristic might be related to children's persistence on a science task, although I did not have strong predictions about the direction of this relationship.

Study 1a

Participants

Overall, 99 participants were collected for Study 1a, with 4 participants excluded from final analysis due to experimenter error. Participants consisted of 95 five- to seven-year-old children ranging in age from 60 to 95 months (*Mage* = 77 months, *SDage* = 10 months; 51 female). Half of the children were assigned to the action-based language condition (*N* = 48) and half were assigned to the identity-based language condition (*N* = 47). In line with previous research utilizing Cox regression survival analysis, this sample size, and specifically within-condition sample size, is sufficient to measure whether children's task persistence differs by condition, child gender, child age, and task accuracy (see Kumar et al., 2022; Rhodes et al., 2019). Eighty-six parents completed a voluntary demographics survey. Of these families, 77% were White, 22% were Asian, 6% were mixed race, 3% were Black, 3% were Hispanic, and 1% was American Indian/Alaskan Native. Families were recruited via Facebook and completed a consent form, approved by the Boston University IRB. All participants received a $15 Amazon gift card for their participation in the study.

Design

Children heard a science storybook that varied based on language type, with half of the participants reading an action-based language storybook, and the other half assigned to read an identity-based language storybook. All storybooks included White, male characters.

Materials

First, the experimenter read a 10-page storybook to the child. The storybook focused on characters who engaged in various scientific activities. The language used in the storybook was either identity-based or action-based (see Table 4.1). Character images were of White, male characters (see Figure 4.1). The first and last pages of the storybook contained images of the group as a whole; the pages in between contained images of individuals or pairs of characters from the larger group.

Page	Identity-Based Condition	Action-Based Condition
1	Let's be scientists. Anyone can be a scientist!	Let's do science. Anyone can do science!
2	Scientists ask questions about the world around them.	People who do science ask questions about the world around them.
3	You can be a scientist by looking at the stars.	You can do science by looking at the stars.
4	You can be a scientist by mixing chemicals together to make an explosion.	You can do science by mixing chemicals together to make an explosion.
5	You can be a scientist by testing how strong a bridge is.	You can do science by testing how strong a bridge is.
6	You can be a scientist by counting the number of leaves on a tree.	You can do science by counting the number of leaves on a tree.
7	You can be a scientist by building a sturdy structure.	You can do science by building a sturdy structure.
8	You can be a scientist by making notes and observations about the animals outside.	You can do science by making notes and observations about the animals outside.
9	You can be a scientist by using electricity to make a lightbulb light up.	You do science by using electricity to make a lightbulb light up.
10	Let's be scientists today!	Let's do science today!

Table 4.1. Storybook words by language condition.

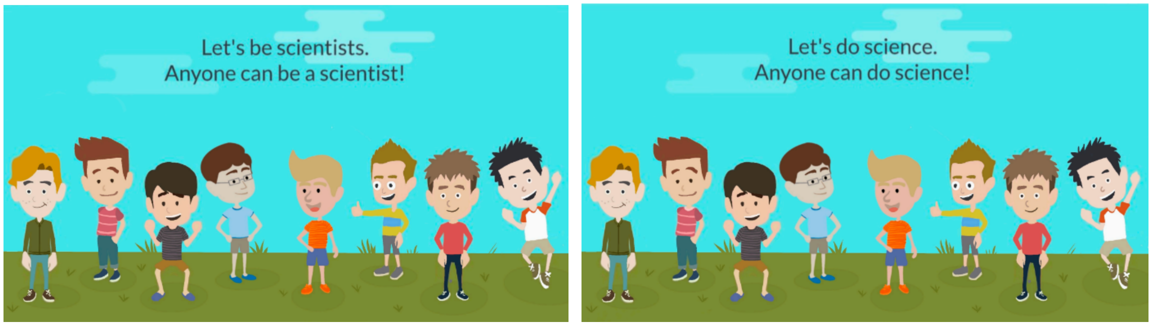

Figure 4.1. Images of storybooks differing by language type in Study 1a (homogeneous, White, male characters).

Procedure

Storybook Reading

The experimenter first read a randomly assigned storybook to children, saying "Today we're going to read a storybook! Let's get started," before reading through the 10-page book.

Group Trait Inference Question

The experimenter then invited children to answer a few questions. Children were shown a picture of the group of scientists from the book. They were then invited to determine they judged the scientists as smart or hardworking, as well as to justify their response.

Interest in Science & Science Self-Efficacy Questions

Children were then shown a four-point scale (see Figure 4.2) and asked two practice questions to ensure that they understood how the scale worked. For example, children were asked, "How much do you like candy? Not at all, a little bit, somewhat, or a lot?" The experimenter pointed to the appropriate circle on the scale as they spoke. Children were then asked to rate how much they wanted to "be a scientist" or "do science" on a 4-point scale, and to rate how good they thought they would be at "being a scientist" or "doing science" on a 4-point scale. These questions were adapted from Lei et al. (2019) who found that children's science self-efficacy and science interest were lower when they were asked about "being scientists" compared to "doing science." Children were asked to justify their responses to both of these questions. The coding scheme for these justifications is detailed below in the Justification Question Coding Scheme section.

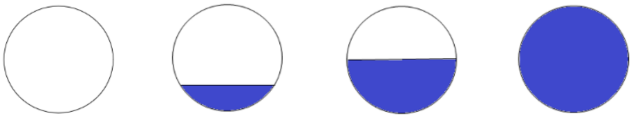

Figure 4.2. The four-point scale experimenters used to ask children to express their science interest and self-efficacy.

Self-Evaluation Question

Children were asked a self-evaluation question: “Do you think *you* are more smart or more hardworking?” They were then asked to justify their response to this question. The coding scheme for these justifications is detailed below in the Justification Question Coding Scheme section.

Mindset Question

Next, children were asked a mindset question (following Bempechat et al., 1991). Children were told that “Some kids say you can get smarter and smarter all the time. Other kids say how smart you are stays pretty much the same.” They were then asked which statement they agreed with. The first option indicated an endorsement of an incremental theory of intelligence; the second option indicated an endorsement of an entity theory of intelligence. Children were also invited to justify their response. The coding scheme for these justifications is detailed below in the Justification Question Coding Scheme section.

Gender Identity & Importance Question

Children were first asked, “Are you [a boy/a girl]?” (matched to their gender, as indicated by their legal guardian on their consent form). Then, they were asked “How important is being [a boy/a girl] to you? Is it very important, a little bit important, or not very important?" Children were asked to justify their responses. The coding scheme for these justifications is detailed below in the Justification Question Coding Scheme section. This question follows Rogers & Meltzoff (2017) who found that children rated gender as a more important identity than race and that children highlighted group differences when discussing gender, but not when discussing race.

Justification Question Coding Scheme

Recall that children were asked to justify their responses to all of the questions above. With the exception of their justification of the mindset question, children's responses to the justification question were coded using a coding scheme that was adapted from previous research exploring children's perceptions of scientists (Kumar et al., 2023). The categories included references to *effort*, *natural ability*, *occupation*, *physical attributes*, *personality traits, gender, intrinsic motivation or preferences,* and *personal connections* (see Table 4.2 for examples). The coding scheme also included an *uninformative* code (e.g., "I don't know" or no response) which was mutually exclusive such that if the justification was uninformative, the response received no other code (see Table 2). We established interrater reliability by having two researchers independently code 10% of the data. Overall, agreement was high for the coding scheme (96% agreement, with kappa = 0.94). Discrepancies were resolved through discussion and then one coder coded 70% of the responses and the other coder coded 30% of the responses.

Code	Example	Mutually Exclusive?
Uninformative	"I don't know."	Yes
Effort	"I work hard."	No
Ability	"I am smart."	No
Occupation	"I want to be an artist."	No
Physical Attributes	"He has brown hair."	No
Personality Traits	"They are happy."	No
Gender	"Girls are better."	No
Intrinsic Motivation	"I want to be a scientist."	No
Personal Connections	"I love watching birds"	No

Table 4.2. Coding scheme and examples.

For the **Gender Identity & Importance Question**, I added an additional code, *references to humanity*, to capture responses that justified the importance of their gender by explaining that we are all human beings. For example, one child said that their gender was important to them "because at least I am still a human, I mean a person."

Mindset Question Coding Scheme. I coded the **Mindset Question** separately from the rest of the questions because children's justifications consisted of different types of responses. I utilized the coding scheme in Paper 2. The categories included references to *learning, stability of intelligence,* and *personal connections* (see Table 4.3 for examples). This coding scheme also included a mutually exclusive *uninformative* category for irrelevant responses or no response.

Code	Example	Mutually Exclusive?
Uninformative	"I don't know."	Yes
Learning	"You can learn stuff."	No
Stability of Intelligence	"When you're a baby you have a certain amount of smart."	No
Personal Connections	"In kindergarten I didn't know how to read, but now I do."	No

Table 4.3. Mindset coding scheme and examples.

Persistence Task

Finally, children were shown the final image of the group of characters in the storybook and were invited to play a science game where they would 'be scientist' or 'do science,' as reflected in the characters in the storybook they had previously read.

The game was a modified version of a Sink or Float task in which children were asked to make predictions about whether objects will sink or float in water. The first trial was rigged so that all children get the first trial incorrect (e.g., if the child says they predict the object will float, the object will sink). Previous work (Kumar et al., 2022) used a version of this task in which children received three levels of feedback (a noise, a check mark or x mark, and experimenter feedback) and found that boys persisted longer than girls. To control for potential gender differences, the task included only one level of feedback: upon the first incorrect response, the experimenter stated, "Your answer was wrong, the object actually floated/sank," before asking if the child wanted to continue to play the game.

Following the first rigged trial, the game was a fair game. The experimenter continued to give children neutral verbal feedback (as prior work has shown that valenced feedback from an adult is received differently by boys compared to girls; Dweck et al., 1978; Dweck & Bush, 1976). There were 16 total trials in the game; after each trial, the child is invited to continue playing the science game or to do something else. I measured the number of trials that children persisted following the first incorrect trial.

Study 1a Results

Study 1a examined whether children's responses and persistence differed after reading a science storybook using action-based language, as compared to reading a science storybook using identity-based language. I analyzed whether there were differences in children's group trait attributions, science interest, feelings of science self-efficacy, self-evaluations, mindset, gender importance, and persistence based on language condition.

Group Trait Attribution

Fifty-four percent of children evaluated the group as hardworking rather than smart, whereas 46% evaluated the group as smart rather than hardworking. A binary logistic regression indicated no difference in children's group trait attribution judgements by age, child gender, or type of language used in the storybook ($\beta = -0.02$, $SE = 0.02$, $p = 0.30$; $\beta = 0.43$, $SE = 0.42$, $p = 0.07$; $\beta = 0.10$, $SE = 0.43$, $p = 0.82$).

Science Interest

An ordinal logistic regression revealed a significant relation between children's reported science interest and the language utilized in the storybook. Relative to the action-based language condition, the odds of being on the lower end of the science-interest scale are greater for identity-based language ($\beta = -1.52$, *SE* = 0.44, $p < 0.001$; see Figure 4.3 for a breakdown of children's science interest ratings by child gender). Additionally, there was a significant relation between child gender and storybook language in this study. Relative to girls, boys were more likely to express lower science interest ($\beta = -0.91$, *SE* = 0.42, $p = 0.03$; see Figure 4.4 for a breakdown of children's science interest ratings by child gender). There was no significant effect of science interest based on age ($\beta = 0.03$, *SE* = 0.02, $p = 0.16$).

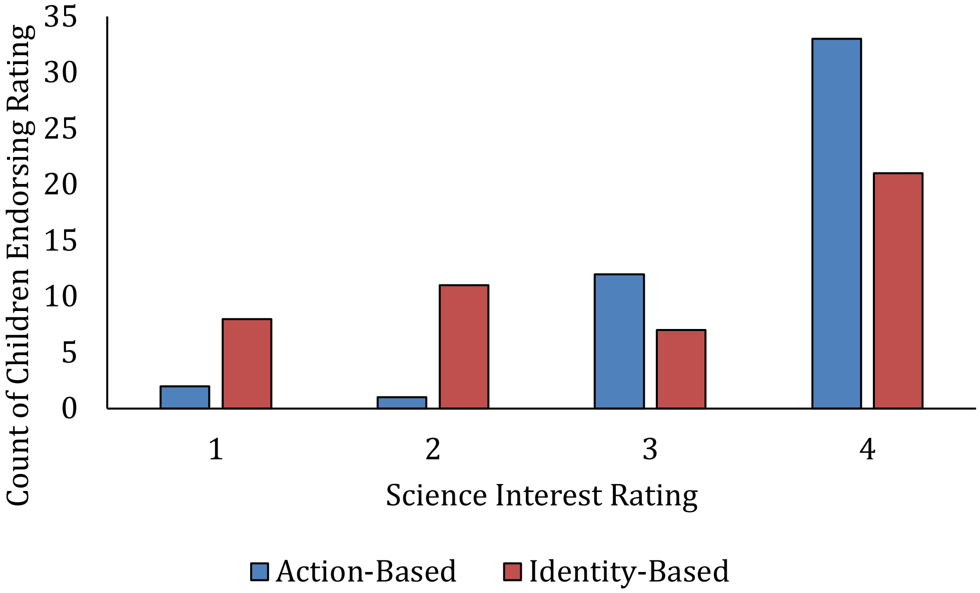

Figure 4.3. Bar graph of children's science interest ratings by language condition for Study 1a. Ratings were on a discrete 1–4 scale.

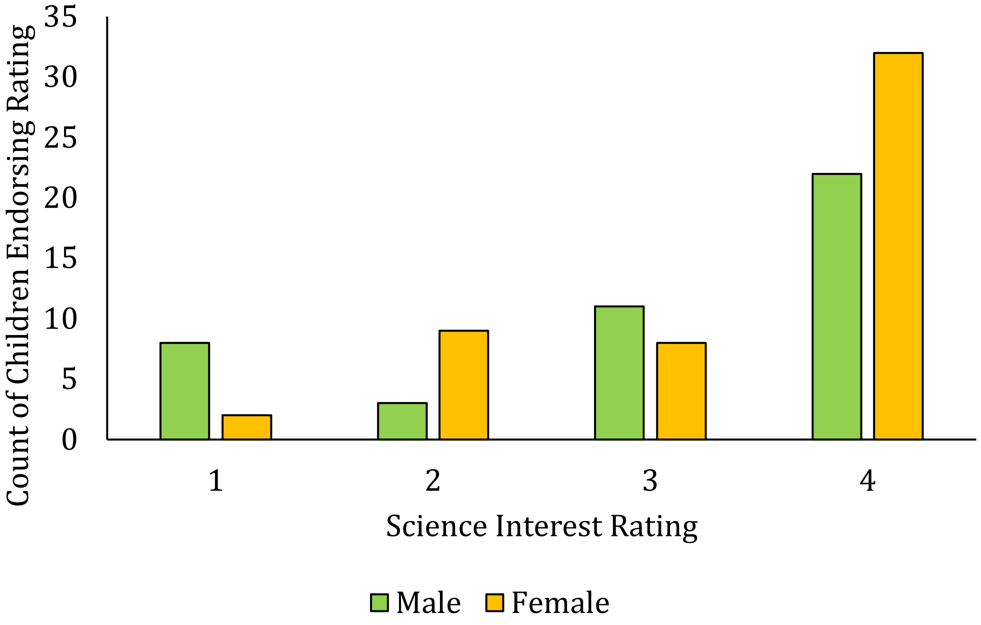

Figure 4.4. Bar graph of children's science interest ratings by child gender for Study 1a. Ratings were on a discrete 1–4 scale.

Science Self-Efficacy

An ordinal logistic regression indicated no significant effect of gender, age, or storybook language on children's reported feelings of science self-efficacy (β = -0.03, *SE* = 0.02, *p* = 0.20; β = -0.10, *SE* = 0.38, *p* = 0.81; β = -0.49, *SE* = 0.38, *p* = 0.20).

Self-Evaluation

Fifty-four percent of children identified as more hardworking than smart. A binary logistic regression showed no difference in children's group trait attribution judgements by age, child gender, or type of language used in the storybook (β = 0.00, *SE* = 0.02, *p* = 0.77; β = -0.15, *SE* = 0.43, *p* = 0.72; β = -0.57, *SE* = 0.43, *p* = 0.18).

Mindset

The majority of children endorsed a growth mindset (78% as compared to 22%).

A binary logistic regression showed no difference in children's mindset attribution by child gender or type of language used in the storybook (β = 0.62, *SE* = 0.52, *p* = 0.23; β = 0.01, *SE* = 0.51, *p* = 0.99), but there was an effect of child age. With age, children were more likely to endorse an incremental theory of intelligence (β = 0.06, *SE* = 0.03, *p* = 0.05).

Persistence Task and Gender Importance

Gender Importance

I conducted an ordinal logistic regression to examine whether there were differences in children's gender importance rating by age, gender, or condition, before using gender importance as a possible predictor of task persistence. Analysis showed no significant difference in children's self-reported gender importance based on age, gender, or storybook language (β = -0.01, *SE* = 0.02, *p* = 0.50; β = 0.11, *SE* = 0.42, *p* = 0.80; β = -0.64, *SE* = 0.42, *p* = 0.12).

Persistence Task

A Cox Regression survival analysis was conducted to examine how children's persistence on the science task was impacted by condition and other variables. Results indicated that persistence on the science task was not significantly predicted by child age, gender, storybook language, gender importance (βage = -0.00, *SE* = 0.01, *p* = 0.50; $\beta gender$ = -0.15, *SE* = 0.24, *p* = 0.53; $\beta language$ = 0.27, *SE* = 0.25, *p* = 0.28; $\beta importance1$ = 0.21, *SE* = 0.32, *p* = 0.52; $\beta importance2$ = -0.40, *SE* = 0.31, *p* = 0.19). Persistence on the science task was significantly predicted by task accuracy; with every one unit increase in persistence on the task, there was a decrease in task accuracy

($\beta accuracy = -0.77$, $SE = 0.53$, $p = 0.15$). In other words, the longer children persisted, the less accurate they were on the task.

Coding Science Interest Justification Questions

I report results regarding children's science interest justifications as there were significant difference by language type and gender for this question.

I first examined the 131 justifications overall. Of these, 25 (19%) were uninformative, resulting in 81% of codes being informative ($N = 106$). I then used the coding scheme to explore percentage of informative responses by category. I found that 19% of informative responses referenced *effort*, 4% referenced *ability*, 11% referenced *occupation*, 0% referenced *gender*, 49% referenced *intrinsic motivation/preference*, and 16% referenced personal connections.

I further explored whether there were differences in children's justifications by language condition. Table 4.4 shows the percentage breakdown of each code by language type.

	Effort	**Ability**	**Occupation**	**Gender**	**Intrinsic Motivation**	**Personal Connections**
Action-Based	55%	75%	50%	0%	58%	35%
Identity-Based	45%	25%	50%	0%	42%	65%

Table 4.4. Percentage of responses referencing each category in coding scheme by language type.

I conducted analyses exploring condition differences in children's justifications referencing *effort, ability, occupation, intrinsic motivation,* and *personal connections.* I did not analyze differences for the gender code as there were no justifications that referenced that code. There were condition differences in children's references to *intrinsic motivation*, with significantly more references to *intrinsic motivation* in the action-based rather than identity-based language condition ($z = 1.96, p < 0.05$). There was no condition difference in children's responses referencing occupation, as an equal number of these codes were in each condition. There were no conditions in children's references to *effort, ability,* or *personal connections* ($\chi^2_{effort} = 0.4, p > 0.05$; Fisher's $\text{exact}_{ability}$, $p > 0.05$; $\chi^2_{personal} = 2.94, p > 0.05$)

Finally, I examined percentages of children's justifications in each coding category based on child gender (Table 4.5). There was no gender difference in children's responses referencing effort or occupation, as an equal number of boys and girls referenced effort in these categories. There was also no significant difference in references to *ability, intrinsic motivation,* or *personal connections* (Fisher's $\text{exact}_{ability}$, $p > 0.05$; $z = -0.40$; $p > 0.05$; $\chi^2_{personal} = 0.12, p > 0.05$).

	Effort	**Ability**	**Occupation**	**Gender**	**Intrinsic Motivation**	**Personal Connections**
Female	50%	75%	50%	0%	48%	53%
Male	50%	25%	50%	0%	51%	47%

Table 4.5. Percentage of responses referencing each category in the coding scheme by child gender.

Study 1a Discussion

In Study 1a I explored potential differences in children's science interest and persistence by language condition when reading a storybook featuring a homogeneous, White, male group of characters. I also measured condition differences regarding whether children viewed the storybook characters as smart or hardworking (group trait attribution question), whether they evaluated themselves as smart or hardworking (self-evaluation question), how important they rated their gender (gender importance question), and theory of intelligence (incremental or entity). The results indicated that there was a significant difference in children’s science interest by condition, with children in the action-based language condition expressing greater science interest than children in the identity-based language condition. Additionally, boys expressed lower science interest than girls across conditions. Finally, it appeared that as children were more accurate on the persistence task, they tended to persist for fewer number of trials. There were no condition differences or differences by gender or age in children’s responses to any other measure.

Why did children express greater science interest in the action-based than identity-based condition? I analyzed children’s justifications by condition to explore this question. There were no significant differences in children’s justifications by condition, suggesting that children could not explicitly articulate the impact of the storybook language on their science interest.

Why was the likelihood of expressing greater science interest higher for girls than for boys across conditions? I analyzed children’s justifications by child gender to explore possible explanations but found no gender-related differences. This may be because children were not explicitly aware of the reasoning behind their choices. Another possibility is that girls and boys were asked to justify their response – but not why they did *not* respond with a higher level of science interest. Future research might probe children’s science interest with other measures.

Finally, why was children’s task accuracy associated with decreased levels of persistence? It seems possible that task accuracy might be related to decreased curiosity. Indeed, recall that after each trial, children were asked, “Would you like to keep playing the science game, or do something else?” Children were not told what “something else” was, but the assumption might have been that it would be a comparable science game or activity that could have been more interesting. To explore this possibility, future work should include a measure of children’s curiosity or desire for novelty.

I was curious about whether children would respond similarly to a storybook focused not on White, male characters, who represent the dominant group in STEM fields in the United States, but instead focused on characters who come from underrepresented groups in STEM such as women and non-White people (NSF, 2023). In particular, I wondered if similar language condition differences in children’s science interest, by which children showed greater science interest in the action-based language condition than in the identity-based language condition, would emerge if the storybook featured diverse characters. Science storybooks can be a valuable way to send young children messages about who belongs in STEM and about the values of the scientific community (Sharkawy, 2009). Prior work has shown that reading science storybooks about diverse characters broadens children’s perceptions of who can be a scientist, although recent research has shown that a majority of trade picture books recommended by the National Science Teachers Association featured White, male characters in science storybooks (Farland, 2006; Finson et al., 2018). Therefore, it seemed possible that reading about diverse characters participating in science could ameliorate hearing identity-based language in a storybook, leading children to express equal levels of science interest regardless of language type. Additionally, I found gender differences whereby young boys in Study 1a were more likely to express lower levels of science interest than young girls. I thought it possible that viewing racially and gender diverse characters participating in science activities could show children that many types of people, including girls, boys, White people, and non-White people, can participate in science. This broadened perception of who can be a scientist might decrease gender differences in science interest.

I remained interested in the effect of action-based and identity-based, especially given mixed findings on the impact of these language types on language on young children's science interest and performance (Gilligan et al., 2023; Rhodes et al., 2019; Rhodes et al., 2020). Therefore, in Study 1b, children were again exposed to a science storybook that differed by language type (either action-based or identity-based). However, rather than featuring White, male characters, the science storybook featured racially and gender diverse characters with the goal of exploring how featuring these characters could ameliorate the gender differences and condition differences by science interest found in Study 1a.

Study 1b

Method

Participants

Overall, 100 participants were collected for Study 1b, with 6 participants excluded from final analysis due to experimenter error. Thus, participants consisted of 94 five- to seven-year-old children ranging in age from 61 to 95 months (*Mage* = 77 months, *SDage* = 10 months; 51 female). Half of children were assigned to the action-based language condition (*N* = 46) and half were assigned to the identity-based language condition (*N* = 48). In line with previous research utilizing Cox regression survival analysis, this sample size, and specifically within-condition sample size, is sufficient to measure whether children's task persistence differs by condition, child gender, child age, and task accuracy (see Kumar et al., 2022; Rhodes et al., 2019). Parents completed a voluntary demographics survey. Of the 88 participants who responded, 67% were White, 24% were Asian, 10% were mixed race, 5% were Black, 3% were Hispanic, and 2% were American Indian/Alaskan Natives. Families were recruited via Facebook and completed a consent form, approved by the Boston University IRB. All participants received a $15 Amazon gift card for their participation in the study.

Design & Materials

The science storybooks children read featured racially and gender diverse characters (see Figure 4.5). Seventy-five percent of characters were non-White and 75% were female. There were no White male characters in the storybook. On all other metrics, the storybooks were identical to those used in Study 1a (see Table 4.1).

Procedure

The procedure was identical to that in Study 1a. The experimenter read the child a science storybook and then asked them the group trait attribution question, questions about science interest and feelings of self-efficacy, a self-evaluation question, a mindset question, and a gender importance question. Finally, children were invited to play the persistence task.

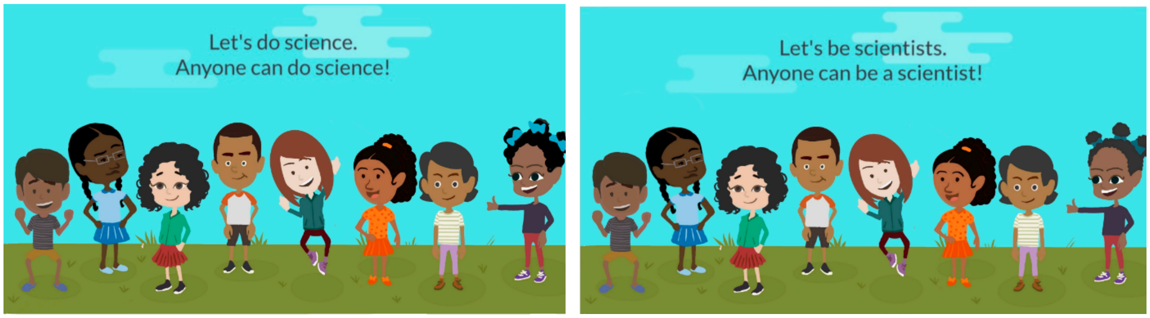

Figure 4.5. Images of storybooks differing by language type in Study 1b (racially and gender heterogeneous characters).

Study 1b Results

Study 1b explored whether children's responses and persistence differed after reading a science storybook with racially and gender-diverse characters using action-based language, as compared to after reading a science storybook using identity-based language. I analyzed differences in children's group trait attributions, science interest, feelings of science self-efficacy, self-evaluations, mindset, gender importance, and persistence based on language condition.

Group Trait Attribution

Forty-nine percent of children evaluated the group as hardworking rather than smart, whereas 51% evaluated the group as smart rather than hardworking. A binary logistic regression showed that there was no difference in children's group trait attribution judgements by age, child gender, or type of language used in the storybook ($\beta = 0.00$, $SE = 0.02$, $p = 0.91$; $\beta = 0.34$, $SE = 0.42$, $p = 0.41$; $\beta = -0.60$, $SE = 0.42$, $p = 0.16$).

Science Interest

An ordinal logistic regression revealed that there was a significant relation between children's reported science interest and the language utilized in the storybook. Relative to in the action-based language condition, children were more likely to express lower science interest in the identity-based language condition ($\beta = -1.03$, $SE = 0.40$, $p = 0.01$). Figure 4.6 displays the distribution of children's science interest ratings. There was no significant effect of science interest based on age or child gender ($\beta = 0.00$, $SE = 0.20$, $p = 0.75$; $\beta = -0.039$, $SE = 0.39$, $p = 0.32$).

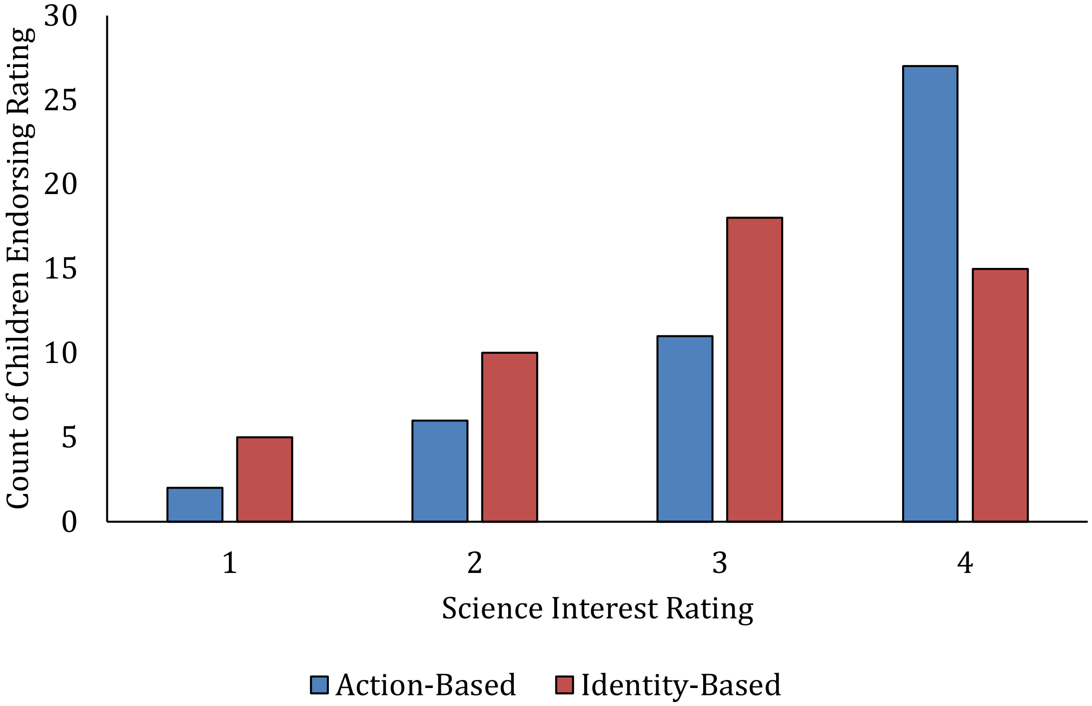

Figure 4.6. Bar graph of children's science interest ratings by language condition for Study 1a. Ratings were on a discrete 1–4 scale.

Science Self-Efficacy

An ordinal logistic regression indicated that there was no significant change in children's reported feelings of science self-efficacy by age, child gender, or storybook language (β = -0.01, *SE* = 0.02, *p* = 0.48; β = 0.24, *SE* = 0.39, *p* = 0.53; β = -0.74, *SE* = 0.40, *p* = 0.06).

Self-Evaluation

Forty-three percent of children identified as more hardworking than smart, whereas 57% identified as more smart than hardworking. A binary logistic regression showed that there were no differences in children's self-evaluation as either smart or hardworking by age, child gender, or type of language used in the storybook (β = 0.04, *SE* = 0.02, *p* = 0.08; *β* = -0.61, *SE* = 0.45, *p* = 0.17; *β* = -0.37, *SE* = 0.44, *p* = 0.40).

Mindset

The majority of children endorsed a growth mindset rather than a fixed mindset (89%, as compared to 11%). A binary logistic regression indicated no differences in children's group trait attribution judgements by age, child gender, or type of language used in the storybook (*β* = -0.05, *SE* = 0.04, *p* = 0.19; *β* = -0.29, *SE* = 0.69, *p* = 0.68; *β* = -0.44, *SE* = 0.69, *p* = 0.58).

Persistence Task and Gender Importance

Gender Importance

I conducted an ordinal logistic regression to examine preliminary differences in children's gender importance rating by age, gender, or condition. Results indicated no significant differences in children's self-reported gender importance based on age, gender, or storybook language (*β* = -0.01, *SE* = 0.02, *p* = 0.81; *β* = 0.32, *SE* = 0.41, *p* = 0.43; *β* = 0.26, *SE* = 0.41, *p* = 0.53). Accordingly, the following analyses were collapsed across these factors.

Persistence Task

Following prior work (Kumar et al., 2022), a Cox Regression survival analysis was conducted to examine how children's persistence on the science task was impacted by condition and other variables. The analysis found that child age, child gender, storybook language, gender importance, or task accuracy did not significantly account for variation in child persistence level (*βage* = -0.01, *SE* = 0.01, *p* = 0.67; *βgender* = 0.03, *SE* = 0.24, *p* = 0.89; *βlanguage* = 0.26, *SE* = 0.24, *p* = 0.29; *βimportance1* = 0.40, *SE* =

0.29, $p = 0.17$; $\beta importance2 = -0.09$, $SE = 0.29$, $p = 0.75$; $\beta accuracy = -0.61$, $SE = 0.53$, $p = 0.25$).

Coding Science Interest Justification Questions

Although I coded for all of the justification questions, I have chosen to report only results from children's responses to the science interest justification question because responses to that question varied by language type.

I first examined the 128 justifications overall. Of these, 24 (19%) were uninformative, resulting in 81% of codes being informative ($N = 104$). I then used the coding scheme to explore percentage of informative responses by category. I found that 23% of informative responses referenced *effort*, 4% referenced *ability*, 11% referenced *occupation*, 0% referenced *gender*, 43% referenced *intrinsic motivation/preference*, and 19% referenced personal connections.

I then further explored potential differences in children's justifications based on language condition. Table 4.6 displays the percentage breakdown of each code by language type.

	Effort	**Ability**	**Occupation**	**Gender**	**Intrinsic Motivation**	**Personal Connections**
Action-Based	42%	50%	27%	0%	62%	55%
Identity-Based	58%	50%	73%	0%	38%	45%

Table 4.6. Percentage of responses referencing each category in coding scheme by language type.

I did not analyze the gender code as there were no codes in that category. Additionally, because there were the same percentage of codes in each condition for the *ability* category, I did not analyze this code. For the *intrinsic motivation* category, results indicated that children justified their science interest using responses that referenced intrinsic motivation significantly more in the action-based than identity-based language condition ($z = 2.32$, $p = 0.01$). There were no significant differences in children's justifications by condition for the *effort, occupation,* or *personal connections* categories ($\chi^2_{effort} = 1.33$, $p > 0.05$; Fisher's exact$_{occupation}$, $p > 0.05$; $\chi^2_{personal} = 0.4$, $p > 0.05$).

Study 1b Discussion

In Study 1a, I asked whether children's science interest, feelings of self-efficacy, and persistence on a science task would vary based on the type of language used in a science storybook featuring all White and male characters. I also measured potential condition differences regarding whether children viewed the storybook characters as smart or hardworking (group trait attribution question), whether they evaluated themselves as smart or hardworking (self-evaluation question), how important they rated their gender (gender importance question), and theory of intelligence (incremental or entity).

I anticipated that children would express greater science self-efficacy and interest in the action-based language condition than in the identity-based language condition, but I had no strong prediction about children's task persistence by condition or gender. This prediction was partially borne out, with children expressing significantly greater science interest in the action-based language condition than in the identity-based language condition. Additionally, there was no difference in children's persistence based on language condition. However, there were no significant difference in children's responses by condition, gender, or age to any of the other questions. I discuss this further in the General Discussion section.

Why did children express greater science interest in the action-based language condition than in the identity-based language condition? Children's justifications of their science interest revealed a significant difference in children's justifications by condition. They were more likely to reference *intrinsic motivation* and personal preference (e.g., "I want to be a scientist") in the action-based language condition than in the identity-based language condition. Perhaps one effect of hearing action-based language that focused on "doing science" was that children felt greater motivation to participate.

The results of Study 1a were somewhat different from those of Study 1b. First, although there was no difference in the effect of task accuracy on persistence in Study 1b, in Study 1a children who were more accurate persisted for fewer trials. It is striking that there were no gender differences in children's science interest in Study 1b but that gender differences did arise in Study 1a. It seems that young boys, but not young girls, were negatively impacted by viewing a storybook featuring all-White, all-male characters. Prior work has hypothesized that when children hear identity-based language (e.g., You are 'being a scientist'), they engage in a mental comparison of themselves and the target group. If they cannot imagine themselves as part of the group "scientists," then they might persist for less time on a task or display less interest (Rhodes et al., 2019). In Study 1b, children had access not just to an imagined target group, but instead to the images in the storybook of White boys. It is possible that when boys viewed characters who shared their gender engaged in specialized science activities (such as building a doghouse, making a volcano, and looking at the stars through a telescope), they reflected on the fact that they had not engaged in these activities before, which might be related to less feelings of belonging. Consistent with this interpretation, only 16% of science interest justifications in Study 1a mentioned personal connections. I expand more on this possibility in the General Discussion.

General Discussion

The present study investigated how linguistic and visual cues in a science storybook influenced children's persistence on a STEM task as well as their beliefs about intelligence, their interest and feelings of self-efficacy in science, their perceptions of themselves and others as smart or hardworking, and their gender importance. In Study 1a, children were read a science storybook that varied by language type (either action-based or identity-based) and featured all White and male characters. Children reported greater science interest in the action-based language condition than in the identity-based language condition. Additionally, boys reported lower science interest across conditions than girls. In Study 1b, children were read identical science storybooks to those in Study 1avarying by language type, but the book featured racially and gender heterogeneous characters. Again, children reported greater science interest in the action-based language condition than in the identity-based language condition. However, there were no differences in science interest by gender in this study. No other significant findings were found.

Why did children express greater science interest in the action-based language condition than in the identity-based language condition in both Study 1a and Study 1b?

This finding aligns with prior research finding that children in middle childhood (ages six to eleven) reported greater science interest after hearing action-based language than identity-based language (Lei et al., 2019). Action-based language allows children to consider science as an activity for all learners, whereas identity-based language suggests that science is only accessible to an exclusive few. Thus, children displayed greater interest in science when it was framed as an inclusive activity. Interestingly, despite expressing greater science interest by condition, children showed no difference in feelings of science self-efficacy by condition. These findings are in contrast to prior research that six- to- eleven-year-old children's feelings of science self-efficacy were greater after hearing action-based than identity-based language (Lei et al., 2019). The differences in findings here may have been because children's reported feelings of science interest and self-efficacy were near ceiling across both Studies.

Why were boys less likely to express greater science interest than girls in Study 1a but no gender differences were found in Study 1b? The key difference between the studies is that in Study 1b, the storybook featured characters who differed by race and gender, with a majority of characters from non-dominant groups (i.e., majority non-White and girls) whereas in Study 1a, the storybook featured all-White, all-male characters. One possibility is that in Study 1a, the imagery of White boys may have specifically made boys feel excluded and uninterested. In prior work where images were not included (e.g., Rhodes et al., 2019), children may have used their mental reference point for who is welcome in science to determine science interest, which may have led to the opposite pattern of findings. A second possibility is that viewing racially and gender diverse characters rather than all White and male characters boosted young girls' science interest across the board. Given the current dataset, it is difficult to determine which of these possibilities is driving this finding, providing an opportunity for future work to explore. These findings tentatively suggest that storybooks featuring characters, especially diverse characters, doing science could be important tools for helping children feel that science is more accessible.

Why were there no significant findings for any of the other measures assessed in these studies, including mindset, group trait attribution, gender importance rating, and task persistence? First, specifically pertaining to the lack of condition differences on task persistence, the storybook reading may have been too brief to have an impact on children's behavior. Prior work examining children's perceptions of scientists based on visual cues similarly found no condition differences on children's task persistence, positing that exposure to visual stimuli needs to be longer and more contextualized to impact behavior (Kumar et al., 2023). Additionally, regardless of condition, the storybooks had a positive message surrounding science and emphasized inclusion. In particular, the storybooks used the second person, telling children that they could do science or be scientists. However, despite the positive messaging, the storybooks overall do focus on the effort that would be needed for a career in the sciences. Prior work has found that emphasizing achievement rather than effort diminished children's persistence on a task (Haber, Kumar et al., 2022). Perhaps in this case, the emphasis on the positive without acknowledging effort may have dampened children's responses to some of the outcome variables. Although some research has shown that mindset is malleable (e.g., Law et al., 2021; Blackwell et al., 2007), mindset may have needed more explicit description (i.e., through specifically focusing on concepts such as the acquisition of new skills) over time through multiple storybook reading sessions. Regarding the group trait attribution, prior work has shown differences in children's trait attributions about whether a single scientist among a larger group of scientists is smart or hardworking (Kumar et al., 2023). Additionally, some work has found that five-to-seven-year-old children are more likely to use diverse evidence than homogeneous evidence when trying to learn about an individual's toy preferences (Christie & Noyes, 2016). In the current set of Studies, children were invited to make inferences about a group, which may have been more challenging to extend to every group member. Future work might target a specific group member within either a diverse or homogeneous group and invite children to make inferences about trait attributions. Finally, research has indicated that gender is a strong and salient facet of identity and is one that children recognize as being divisive (e.g., Rogers & Meltzoff, 2017; Shutts et al., 2013; Shutts, 2013). Thus, gender importance may not be a malleable trait or something that could be easily changed by a very brief intervention.

Limitations & Future Directions

There are limitations to these studies. First, this research took place over Zoom. Although Zoom data collection allows for a more geographically diverse sample than is typical for this type of research, it limits participation to individuals who have access to certain technologies (such as computers and a strong Wi-Fi connection) and who are inclined to join parenting or developmental psychology research related Facebook groups or respond to boosted posts on Facebook (as much of online recruitment occurs through Facebook). Additionally, developmental research is typically comprised of samples from WEIRD (Western, Educated, Industrialized, Rich, Democratic) populations (Henrich et al., 2010) and data collection via Zoom has not been shown to attract a more racially or socioeconomically diverse sample than is typical (e.g., Bambha & Casasola, 2021). Indeed, across Study 1a and Study 1b, the majority of participants were White. More research should determine whether these findings would extend to children from other racial and ethnic groups.

Another limitation is the consideration of gender as binary. Currently there is little work on how transgender and nonbinary children might respond to gender stereotypes in the domain of science, although there is research indicating that transgender children and their siblings endorse gender stereotypes less and view violations of gender stereotypes as more socially acceptable (Olson & Enright, 2017; Rubin et al., 2019). Future work might consider how transgender children respond to gender stereotypes and exclusive language related to science.

Finally, given the brevity of the storybook, it is unclear whether the impact of the storybook reading has a long-term effect on children's persistence and beliefs. Future work should consider more long-term studies exploring children's outcomes after reading the storybook at multiple time points.

Implications

There are applied implications of this work for educators and caregivers. First, these findings highlight the role of storybooks as a tool that can affect children's science interest depending on the language and images used. The results suggest that science storybooks about racially diverse characters described using action-based language can positively impact children’s interest in science. Parents and early childhood educators should read science storybooks to young children that emphasize science as an activity that anyone can do, rather than as an identity. Additionally, parents and teachers should highlight storybooks like those in the Ada Twist, Scientist series that portray racially and gender diverse characters. It is striking that boys were negatively impacted by reading a science story with all-male characters. This finding shows that boys may be more influenced by the images they see surrounding STEM then we realize and that boys also benefit from viewing inclusive imagery related to science.

In addition, it would be worthwhile to consider how a parent-child dyadic storybook reading, rather than an experimenter-led storybook reading) might impact children’s science interest. Past work has shown that parent-talk during a science storybook reading, above and beyond the content of the book, has predicted children’s performance on a science task (Leech et al., 2020). One could imagine parents reading an action-based language storybook might pause to talk with their children about their children’s science interest or make connections between the story and the child’s life that might help children feel more included and connected to the text. Along these lines, it could be fruitful to ask early childhood educators to read the story with their classes either in small groups or during circle time (whole class discussion) and explore how teacher explanations shift in conjunction with storybook content. Overall, future work should examine how storybooks that use inclusive language and images can be utilized to encourage children’s participation and feelings of belonging in STEM.

CHAPTER FIVE

Significance and Implications

The final chapter of this dissertation focuses on the significance and implications of this work for early childhood educators, caregivers, and children. First, I will consider the findings from each paper and their implications for psychology and education. Then, I will conclude with connections between the three papers, overall implications of this dissertation, and future directions for this research.

Paper 1

Paper 1 investigated children's perceptions of scientists in groups that varied based on gender. This paper had two primary findings. First, results showed that children's attributions of individual scientists as smart or hardworking differed based on the gender of the individual and the gender of the group. Children who viewed a homogeneous gender group of scientists judged a highlighted individual as hardworking rather than smart. By contrast, they judged a lone female scientist among an all-male group as smart rather than hardworking. However, when they viewed a male scientist among an all-female group, they were as likely to judge the male scientist as hardworking as to judge him as smart. Further, although children's trait attribution judgements differed based on group gender composition, their persistence on a science task did not.

Implications for Psychology

A few clear implications for the field of social cognitive development emerge from Paper 1. First, this paper provides further support for the idea that young children use group context to make inferences about group members (e.g., Hermann et al., 2017;

Kinzler et al., 2011). Children are able to reason about what factors, such as intelligence or effort, would lead to an individual's success in STEM. Additionally, the fact that children's trait attributions about a male versus a female scientist differed depending on group context suggests that children are able to consider how larger social inequities (in this case, the lack of women in STEM) might impact men and women differently.

Understanding the mechanisms underlying an effect is critical to building an understanding of how young children think and of ultimately developing interventions that target the appropriate construct. For example, Rhodes et al. (2019) posits that the underlying mechanism for why girls persist longer at a task after hearing action-based language than after hearing identity-based language is because when they hear identity-based language, they reflect on whether they could belong to the larger group and, if they cannot, then they will be less likely to persist. This explanation is plausible and has an impact on our understanding not only of girls' responses in STEM contexts, but of the thought process of underrepresented groups when presented with identity-based language (regardless of whether the context is STEM or not). However, this explanation would be bolstered by evidence of children's thought processes in addition to children's behaviors. Asking children to justify their response using developmentally appropriate language is one way that developmental researchers can evaluate what young children are thinking. Paper 3 asked children to justify their reasoning on the trait attribution, providing further insight into the mechanism associated with children's trait attributions. Although there were no significant findings, there were interesting trends in how children justified their responses differently by condition. These trends, as discussed in the Discussion section of

Paper 1, provide a needed perspective on exactly how children reason when making trait attribution judgements. In fact, although more work is needed, these trends provide some support for the hypothesis that children conflate males with the group “scientist” by showing that children’s responses referenced occupation more when discussing the White male scientist among a group of all-female scientists.

In Paper 1, boys persisted longer than girls on the science sink and float game, regardless of condition. This finding suggests a need for more work exploring how different types of feedback may impact boys and girls differently, especially within the domain of STEM. Prior work has explored how praise and negative feedback can impact children differently based on gender (e.g., Dweck et al., 1978). Specifically for research in STEM, where girls are an underrepresented group, it seems possible that receiving negatively valenced feedback could be a particular deterrent to girls’ willingness to persist on and engage with a science task. I expand on how future research should explore the socio-emotional component of motivation in the face of challenges in the Future Directions section.

Additionally, these findings surrounding feedback suggest that researchers should thoroughly consider how the feedback they provide to participants in their studies may impact children differently depending on gender. It is best and standard practice in social cognitive development labs to provide young children with neutral feedback rather than praise during the course of a study (e.g., saying “okay,” “thank you,” or not responding rather than saying “good job”). However, if researchers are using games or activities developed outside the context of research, they should think deeply about whether the feedback provided within the game is developmentally appropriate and calibrated to provide the level of praise (or lack thereof) that they want. In the case of Paper 1, I created my own version of an already existing Sink or Float app that provided the experimenter with more control over the game. However, because of the finding of gender differences in Paper 1, I further adapted the game in Papers 2 and 3 such that children received neutral feedback from the experimenter.

Implications for Education

Paper 1 also has implications for educational settings. First, this paper showed that children's beliefs about scientists' traits vary based on the group within which the scientists are situated. Thus, early childhood educators should consider how they discuss scientists in the classroom and how they portray scientists. For example, in a discussion of scientists, educators should focus on both male and female scientists. Additionally, if educators display posters or images of scientists, they should be sure to display a balance of genders. The findings from Paper 1 suggest that visuals of groups of scientists may impact children's perceptions of scientists but not their behaviors related to science. Other work has shown that emphasizing the process of research, modeling persistence, and allowing children room to tackle challenges without help are ways to encourage persistence in infants and young children (e.g., Haber, Kumar et al., 2022; Leonard et al., 2017; Leonard et al., 2021). Thus, educators must supplement visuals in the classroom with other language and actions utilized in the classroom.

Moreover, educators should consider focusing not only on the individual scientist (e.g., Albert Einstein) but also a larger discussion of the social context in which the scientist conducted research and focusing on scientists from underrepresented groups in STEM, such as women, transgender, and non-White individuals. Acknowledging that scientists are part of a large, diverse group and that science is a collaborative practice could counteract the narrative that scientists are lone wolf geniuses who simply sit down on their own and emerge with brilliant new ideas rather than people working together to understand the world around them (see Sharkaway, 2009).

This paper also indicated that in early childhood, young children's ideas about ability and effort are forming and they are aware of larger social group dynamics and how these dynamics impact ability and effort. Although much of the research on gender differences in STEM occurs with adults or adolescent populations, early childhood educators should be aware that these gender differences impact young learner's ideas about what is required for a male or female scientist to achieve success in STEM. It could be useful to develop a professional development module for early childhood educators focused on exploring and interrogating their beliefs about girls' and boys' beliefs about science so that they could develop ways to encourage effort and hard work as keys to success for everyone in science.

Finally, this paper found a large gender difference in young children's persistence on the science task, with boys persisting significantly longer than girls on the task. I attributed this difference to the intensity of feedback children received. Anecdotally, it seemed as though young girls responded to failure on the task with negative emotions. Thus, early childhood educators should be thoughtful about how they provide feedback to young children, especially within the domain of STEM. For example, teachers should consider including multiple different ways of providing intellectual feedback within the classroom; for example, fifth-grade girls have been shown to improve rapidly following peer feedback rather than teacher feedback (Dweck, 1976). Additionally, girls and boys have been shown to attribute failure feedback differently, with girls attributing failure feedback from adults to a lack of ability (Dweck, 1976). Thus, it might be useful to provide children with "wise feedback" that explicitly recognizes that the teacher believes children can improve through hard work and effort (see Yeager et al., 2014 for more on wise feedback).

Paper 2

In Paper 2, findings indicated that children preferred a scientist whose natural ability, rather than hard work and effort, was emphasized when deciding between which scientist to ask a science question. Additionally, children preferred the Ability Informant when deciding who they would ask further science questions to in the future. When deciding who to learn a novel word from, children showed no informant preference. These findings are in line with recent work showing that young children have a "naturalness preference," appearing to view an individual with natural ability as smarter and more competent than a hardworking individual (Ma et al., 2022).

Paper 2 also explored children's mindset, finding that children's mindset was not associated with children's decisions about from whom to learn. In line with prior work, most children endorsed a growth mindset (PISA, 2018). This paper provides a new way of understanding how young children understand growth versus fixed mindset, showing that children who endorsed a growth mindset were highly likely to justify their response by referring to learning as a mechanism for becoming smarter and smarter over time.

Finally, Paper 2 considered how children's responses on the selective trust task related to their responses to the explicit judgement questions and to children's mindset by grouping children into one of three profile categories: Neutral, Effort-Oriented, or Achievement-Oriented. Children's profiles did not consistently relate to their responses on the other questions. However, the profiles provide insight into the complexity of children's understanding of effort and ability, suggesting that they do not view effort and ability as mutually exclusive or as unrelated traits.

Implications for Psychology

A few implications for social cognitive development arise from Paper 2. This work builds on prior selective trust research finding that children have preferences for competent, expert individuals (e.g., Sobel & Corriveau, 2010; Leonard et al., 2019). Prior work has explored children's preferences for a naturally brilliant individual over a hardworking individual in the domain of social relationships (Ma et al., 2022). This paper considered children's views of brilliance and effort in the context of STEM, examining children's trust in smart versus hardworking scientists. Ability and effort are especially important in the domain of science. Specifically, although scientists are viewed as brilliant geniuses, effort is actually critical and fundamental to success in STEM (Chestnut et al., 2015). This paper showed that the weight children place on ability and effort may vary depending on the context: for example, children may consider ability and effort to be equally relevant when learning a novel word, but may weigh ability as more important when asking a science question.

This paper, like Paper 1, asked children to justify their selective trust endorsements and explicit judgements. These justifications provide more depth to our understanding of why exactly children showed a preference on average for the Ability Informant, showing that their justifications heavily relied on references to ability such as saying that the scientist they chose was smart.

In this paper, children were also invited to respond to a forced-choice mindset question (Bempechat et al., 1991) and to justify their responses, which provided an opportunity to learn more about young children's mindset. The development of mindset beliefs in early childhood is understudied and there are few measures available that provide a reliable and valid way of assessing young children's mindset, although the field is developing developmentally appropriate measures of mindset in early childhood (consider Muradoglu et al., under review; Ruzek et al., 2020). Additionally, the majority of mindset interventions have focused on older children and adolescents, though mindset has been shown to be critical to children's success and performance in school, including specifically in the domain of STEM (e.g., Blackwell et al., 2007; Yeager et al., 2019). This study also asked children to justify their responses to the mindset question; prior work has not examined children's justifications for why they support a growth or fixed mindset. Thus, this study takes an important step toward understanding what exactly young children mean when endorsing one mindset over another.

As stated previously in this dissertation, motivation is "a constellation" of beliefs and behaviors that relate to achievement (Bempechat & Mirny, 2005). One star in this constellation encompasses our beliefs and attributions of others' success: are they smart or hardworking? How did they become smart or hardworking? Can they become more smart or more hardworking? When we are learning something new, should we trust the information they provide? This last question is central to Paper 2 and Paper 2 shows us that children make decisions not only based on stated outcomes (i.e., both scientists in the study are at the top of their class) but on the causal antecedents of those outcomes (i.e., is the scientist successful due to intelligence or effort; Graham, 2020). Paper 2 found that children do systematically prefer to ask science questions to a smart scientist rather than a hardworking scientist.

However, I wanted to consider children not as a monolith but as coming from different backgrounds that might impact their preferences and trust. Thus, I grouped children into novel profiles indicating whether they selectively trusted the Ability Informant, Effort Informant, or whether they had no preference. Although it is uncertain whether these profiles have a meaningful impact on how children make decisions beyond the study in Paper 2, it is reasonable to consider how a preference for a smart person or a hardworking person might shape future decisions, preferences, or interests within the domain of STEM. For example, might children who prefer to learn from someone smart also view intelligence as a key to success more than children who have no preference? In that case, those children may be particularly discouraged upon facing challenges. Within STEM, which requires a great deal of effort despite being viewed as an area requiring innate ability, Ability-Oriented children could be more easily deterred in science than others.

Implications for Education

As with Paper 1, Paper 2 also has some implications for educational settings and early childhood educators. First, young children showed a preference in asking questions to a smart scientist rather than a hardworking scientist. This suggests that young children value the scientists' domain specific ability, at least in the context of asking a science question. It would be helpful for early childhood educators to consider how they are teaching about ability and effort in classrooms. For example, are ability and effort viewed as mutually exclusive? Scientists are often thought of as innately brilliant, but early childhood could be an excellent time to intervene and highlight that scientists are also hardworking, and that hard work should be weighed as something valuable when it comes to learning from others. Teaching this to children might be as simple as referring to scientists as smart *and* hardworking, or discussing how being hardworking is a way that people can be smart as well.

Additionally, Paper 2 considered children's mindset and showed that children who endorsed a growth mindset frequently referenced learning and going to school as a key justification for how we can get smarter and smarter over time. Growth mindset has been linked to greater academic success, especially for students from underrepresented groups, and can be encouraged in classrooms through relatively easy to implement and cost-effective interventions (e.g., Hecht et al., 2021; Yeager et al., 2019; Zhu et al., 2019). The majority of this research has been conducted with high school students; one study conducted a growth mindset intervention in a museum context for children in middle childhood, but there is room for researchers to explore growth mindset interventions in early childhood educational settings (Law et al., 2021). Indeed, early childhood educators are interested in ways to develop children's growth mindset in the classroom (Boylan et al., 2018; Sun, 2018). However, growth mindset may be particularly important in the context of science learning in early childhood. Thus, it would be useful to develop an integrated and interdisciplinary growth mindset curriculum that prompts discussion of the importance of learning from our mistakes and using mistakes as an opportunity for learning. Such a curriculum could be embedded into science lessons in early childhood and would likely be easily related to an inquiry-based science curriculum. For example, many early childhood classrooms conduct a classic experiment of seeing if a seed will grow into a plant. In this case, educators could make a point of considering why certain seeds might not have grown and point to the fact that the failure of the seeds to grow allows us to ask more questions about what conditions seeds need to thrive. Additionally, this could yield an opportunity to introduce experimental conditions in a developmentally appropriate way by asking children what will happen if some of the seeds do not receive sunlight or if some do not receive water and then demonstrating the consequences with some of the seeds.

Paper 3

Paper 3 examined how a science storybook featuring action-based or identity-based language related to children's science interest, feelings of self-efficacy in science, and persistence on a STEM task. In Study 1b, the storybook featured racially and gender diverse characters. In line with prior work, findings indicated that children expressed greater science interest when reading a storybook with action-based language than identity-based language (Lei et al., 2020). Further, children in the action-based language were more likely to justify their responses by referencing intrinsic motivation and personal preference than children in the identity-based language condition. In Study 1a, children were again exposed to either action-based or identity-based language; however, in this case, the storybooks featured all-White and all-male characters. As in Study 1b, children in Study 1a showed greater science interest when exposed to action-based language than when exposed to identity-based language. Additionally, in Study 1a, boys expressed lower levels of science interest than boys across language conditions, indicating that boys may have been negatively impacted by viewing images of all-White, all-male characters in the storybook.

Implications for Psychology

Paper 3 investigated how a science storybook focusing on characters who are child scientists can influence young children's science interest, feelings of self-efficacy in science, and persistence on a science task. In the field of social cognitive development, storybooks have been utilized as a tool for teaching scientific concepts such as natural selection to young children (e.g., Emmons et al., 2018; Kelemen et al., 2014). Previous work on science storybooks has also investigated features of the story that enable transfer from the storybook to the real world (see Strouse, Nyhout, & Ganea, 2018 for a review). Additionally, the language utilized in science storybooks has been shown as a critical component in children's successful acquisition of scientific concepts (e.g., Leech et al., 2020). Little work in social cognitive development has explored not only how storybooks can be used to help children learn scientific concepts but also how they can be used to develop children’s motivation in science. Some of my prior work has examined this potential use of science storybooks, showing that children persist longer after reading a storybook about a famous scientist who has to work hard to succeed rather than a storybook about a famous scientist who succeeds effortlessly (Haber, Kumar et al., 2022). Paper 3 adds to the idea that science storybooks, and especially the language used in storybooks, can be used as a tool for increasing children’s science interest.

Additionally, Paper 3 provided mixed evidence related to a growing body of work showing how the use of action-based language when discussing science activities in early childhood can be utilized to increased science interest and persistence (e.g., Gilligan et al., 2023; Rhodes et al., 2019; Rhodes et al., 2020; Lei et al., 2020). Here, I found a weak effect of language, whereby action-based language increased children’s science interest but not feelings of self-efficacy or persistence on a STEM task.

Paper 3 also has implications for social cognitive development related to gender differences in STEM activities. In Study 1a, boys were more likely to express decreased science interest compared to girls. This finding has two primary implications. First, it suggests that the images used in a science storybook can impact children’s interest in science. Second, prior work has showed differences wherein girls but not boys persisted for less time on a science task. This study shows that boys can also be negatively impacted by an emphasis on White males in STEM.

Implications for Education

Paper 3 reinforces the idea that action-based language is critical for young children’s developing interest in science. Thus, although early childhood educators, museum educators, and caregivers may be tempted to ask children to step into scientists' shoes and "be scientists," a focus on science as an action ("doing science") is the most efficacious way to encourage science interest. There are teacher trainings in using action-based language that could be useful professional development tools (e.g., Rhodes et al., 2020).

In addition to utilizing action-based language across the board when discussing science, this paper shows that storybooks can be helpful tools for encouraging children's science interest. Storybooks are commonly used in early childhood educational settings as a way to help children learn about topics ranging from vocabulary to social emotional skills to scientific concepts. Paper 3 provides evidence that they are also useful for helping children develop an interest in science from a young age.

Additionally, Paper 3 demonstrates that it is critical for children to see a diversity of races and genders represented in their storybooks. Popular storybook series like the "Ada Twist, Scientist" series could be a wonderful way to introduce children to diverse depictions of scientists. Further, some work has shown that in elementary school, reading storybooks about science and scientists along with a science lesson leads to a broadening of children's conceptions of who can be a scientist (Farland, 2006). Thus, it could be helpful to integrate storybook reading about a diverse group of scientists with science lessons.

Connections Across Papers

To return to one of the primary motivations for each of the three papers in this dissertation, women and non-White people are underrepresented in STEM fields (NSF, 2021). At this time 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 work force (e.g., NSF, 2023; Building Blocks of STEM Act). Researchers and policymakers alike are beginning to recognize that the roots of the gender disparity in STEM begin in early childhood. Thus, early childhood is a critical moment for intervening and fostering a lifelong interest in and engagement with STEM. Some researchers have suggested that perhaps girls simply prefer non-STEM fields and therefore when provided with options between STEM and non-STEM pursuits, they choose not to pursue STEM (Stoet & Geary, 2018). However, this perspective does not align with the negative impact that broad and untrue stereotypes surrounding women and non-White people in STEM have on young children. 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., Rhodes et al., 2019; Lei et al., 2019; Bian et al., 2017).

A central theme across the three papers in this dissertation is a focus on young children’s beliefs and behavior in the domain of STEM. STEM is a particularly interesting domain in which to study how children learn for a few reasons. First, STEM is highly stereotyped and disproportionately composed of White males (NSF, 2023). Thus, research on STEM learning that is aware of these stereotypes and unique social demographics can contribute to our larger understanding of how social group membership or lack thereof impacts motivation and participation. Second, the underrepresentation of women in STEM is a pressing social issue. Closing the gender gap in STEM will bring the United States closer to gender parity, but right now gender parity in STEM is not likely for several more decades. Additionally and relatedly, this dissertation focuses on early childhood. Why? Although much of the research on the STEM gender gap is with adults or high school students, a growing body of research suggests that young children are aware of and responsive to STEM stereotypes much earlier, as young as age 6. Thus, research on children's STEM learning, interest, persistence, and self-efficacy in the preschool and early elementary years is a critical piece of the puzzle when it comes to solving the problem of the STEM gender gap.

Another important theme is that fostering a sense of belonging and membership is an important way to increase children's participation. Paper 1 shows how the lack of women in STEM shifts how children conceptualize the few women who are highly successful in STEM. Paper 2 provides insight into how children selectively choose to learn from smart versus hardworking scientists. In a few ways, Paper 3 shows how small shifts in language can lead to large impact for children's science learning and feelings of inclusion. First, Paper 3 confirms the finding that children who hear action-based language perform better on a science task than children who hear action-based language. Second, Paper 3 shows how racially and gender diverse characters, in addition to language cues, can make boys and girls feel a greater sense of science interest in STEM. Third, Paper 3 presents storybooks as a resource for classroom educators and caregivers to use that can supplement the messages they are sending children about who belongs in STEM and who does not.

A final theme tying the three papers of this dissertation together is that relatively small environmental changes can greatly impact children’s persistence in and beliefs about STEM. Paper 1 provides new evidence for how children’s understanding of scientists changes depending on the gender composition of the scientist group. Paper 2 illuminates how the language a person uses to describe a scientist (either as smart or as hardworking) can change children’s preference to learn from that scientist or not. Paper 3 explores how the combination of inclusive rather than exclusive language and images in a storybook can boost children’s persistence and interest in science. In combination, this work shows how adults such as parents and teachers can modify their language as well as the types of images and storybooks they share with young children in order to nurture an interest in science from a young age.

CHAPTER SIX

Future Directions & Conclusion

To conclude, I consider a few large future directions of this work. In my work, I intend to continue to explore how adult language acts as an important and potentially malleable mechanism through which gender stereotypes are transmitted in STEM domains. I also aim to ask how children's understanding of social group dynamics, such as the relative lack of women scientists, influences their perceptions, sense of belonging in, and ultimately their motivation in STEM.

Expanding Methodologies

This dissertation focuses on three cross-sectional, experimental studies. I believe that it is critical to utilize multiple methodologies, including survey work, naturalistic observation, and experimental approaches, as an iterative process of capturing the lived experiences of STEM learners and understanding avenues for increasing young children's STEM motivation. Below, I expand on methodologies that are relevant to the papers in this dissertation.

For the papers detailed in this dissertation, I believe that longitudinal research is important and necessary. For example, we found that action-based language in a science storybook increase children's science interest. This effect occurred after a very brief, one-shot storybook reading with an experimenter. In future, it would be useful to see whether the effect of the storybook on science interest holds across weeks, months, or even a school year. Additionally, research might look at expanding the intervention; for example, children's interest might increase over time if researchers read the storybook with children every day for one week. Research on five- to eight-year-old children's ability to learn about natural selection through a science storybook reading provides a potential template for conducting longitudinal storybook interventions in early childhood educational settings. Researchers demonstrated that young, school-age children, not typically taught a supposedly too-complicated topic like natural selection, were able to learn, transfer, and retain information about natural selection quickly and after a one-month gap (e.g., Emmons et al., 2018).

I also think that research on parent-child dyadic interactions during a storybook reading could be a fruitful and relevant avenue for exploration. In the current studies, the experimenter either read the storybook to the child (Paper 3) or described the informant (Paper 2), with no additional language input beyond the pre-determined script. How might parents supplement science storybook readings that utilize action-based versus identity-based language? For example, might parents reading action-based language provide more connections between the child's experiences and the storybook, leading to more pronounced differences in science interest by condition?

Additionally, I would like to conduct teacher-based interventions in early childhood educational settings including preschools and early elementary classrooms. For example, it would be interesting to ask teachers to use a science storybook using action-based language or identity-based language and featuring either heterogeneous or homogeneous characters during a science lesson and measure teacher language during the storybook as well as children's science interest, feelings of self-efficacy, and persistence following the intervention. It would also be interesting to ask teachers to incorporate multiple science storybooks that emphasize the process of science across their science classes over the course of a year and see how that relates to children's mindset, science interest, and overall science learning. Such a large-scale intervention could also allow the opportunity to explore which features of a science storybook have a positive impact on children's science interest (e.g., what about a science book featuring fantasy characters rather than humans or a science book focusing on effort rather than achievement; see Strouse et al., 2018 for a review of transfer).

Finally, it could be useful to explore how teacher beliefs and attributions of success and failure in early childhood settings relate to their beliefs about scientists, their pedagogy, their language when discussing science, and the types of questions they ask students. This research could be conducted through a mix of surveys asking teachers about their beliefs as well as observation of classrooms and especially the science areas of preschool classrooms. For example, I have one paper under review that uses observational data showing that in the science areas of a preschool classroom, teachers directed more scientific questions to boys than to girls (Kumar, Haber et al., under review).

Unpacking Children's Ability and Effort Beliefs

There are several constructs explored within this dissertation that were touched on but, due to the scope of the research questions asked, were not fully unpacked. First, it would be useful to consider the socio-emotional component of responding to failure and challenges. Children may be told to try their best even if they make a mistake but may not be given the tools to respond to the emotional distress that failure can cause. Failure should be considered as a multi-faceted construct that involves not only a tangible outcome (a task being completed or not, e.g.,) but also an emotional outcome (e.g., feeling sad or angry). In early childhood, children are developing skills surrounding social emotional regulation, like recognizing what emotions they are feeling and how to deal with them in appropriate ways (e.g., Hoffman et al., 2020). Researchers are exploring the question of how STEM and STEAM (Science, Technology, Engineering, Arts, and Technology) programs can be integrated with social-emotional leaning principles and of which component of social-emotional learning are particularly useful in STEM across development, although the focus appears to be on older children and adults (Garner & Gabitova, 2022; Garner et al., 2018). It seems possible that if the socio-emotional component of failure is acknowledged by adults, young children may be able to recognize feelings of sadness or anger as normal parts of failure rather than as feelings to be avoided at all costs.

Additionally, Paper 2 focuses on children's perceptions of smart versus hardworking scientists. However, despite it being the norm within the field to treat ability and effort as separate constructs, these constructs are not at odds with each other. Although it is useful to ask children forced choice questions in order to develop a clear understanding of children's general tendencies, these forced choice questions may not illuminate the full richness of children's ideas about what it means to be smart and hardworking (Kumar et al., 2022; Bian et al., 2017). For example, young children may recognize that someone who works hard is also becoming smarter through the process of hard work. Beginning to unpack this construct could be as easy as providing children with the opportunity to say that they or another person is “smart, hardworking, or both.” Providing the “both” option allows for the idea that ability and effort can and often do coexist.

Another area of consideration is exploring children’s understanding of structural barriers to success, especially in the domain of science. Intelligence and effort are not the only factors contributing to success and in fact may be misleading. For example, a student might be smart and hardworking, but unable to learn how to do computer science due to the lack of a computer science course in their high school. Research in cognitive development has explored children’s ability to recognize structural constraints of a situation and use that knowledge to inform their understanding of the relation between a category and a property (e.g., Vasilyeva et al., 2018). Imagine possible explanations for the observed relation between a category, gender, and a property, being a scientist. Why, one might wonder, are boys mostly scientists and girls mostly not? An internalist explanation would attribute this pattern to personal preferences: boys are scientists because they like science and girls are not scientists because they do not like science or like other things more. A structural explanation would take external factors into consideration: for example, teachers might have discouraged girls from taking computer science classes but encouraged boys to do so. Researchers have shown that children are capable of engaging in structural thinking from as young as three-years-old (Vasilyeva et al., 2018). By five-years-old, children largely respond to scenarios involving structural constraints like adults. Thus, it would be interesting to see if children are aware of structural barriers to success in STEM, especially for individuals for underrepresented groups. For example, would children be more likely to provide structural or internalist explanations for a scientist's success in STEM? And would their explanations differ depending on scientist gender (e.g., would they be more likely to attribute structural explanations such as access to resources to females than to males?).

Finally, it would be interesting to investigate increasing children's feelings of relatedness as a key way to increase their motivation in STEM, especially for children from underrepresented groups in STEM. This work should consider Self Determination Theory (SDT), which posits that satisfying a need for relatedness, or perceiving oneself as belonging in some way, can boost intrinsic motivation in children and adults (e.g., Ryan & Deci, 2000; Anderson et al., 1976). Thus, one potential way to promote science learning is to increase children's intrinsic motivation through enhancing their feelings of relatedness. For example, prior research has found that being a member of a social group increases children's engagement in a science task (Master & Meltzoff, 2017). Haber, Kumar et al. (2022) posited that one reason that children might have persisted longer on a task after reading a storybook about a famous scientist who faced challenges on the path to success is that children were able to relate to the scientist more than after reading about a scientist who achieved effortlessly. In this case, "feelings of relatedness" might be operationalized as the ability to make connections to personal experiences. Right now, we have an in-progress study examining how providing explicit opportunities for children to make connections between themselves and a famous scientist during a storybook reading might boost persistence and science interest (e.g., by asking children, "Can you think of a time that you made a mistake, just like Marie Curie?"; Kumar, Haber et al., 2022).

Focusing on Underrepresented Groups

An important and needed direction for this work is to focus primarily on children from underrepresented groups in STEM, including non-White children, girls, and children from low-income backgrounds. The current studies were able to explore girls' STEM motivation and persistence, but the majority of children were White and came from highly educated families, meaning that they were not representative of the population in general. As described in the Limitations section of these papers, the findings here cannot be generalized to other populations. Future work should be dedicated specifically to exploring what factors can increase interest and motivation in STEM in children from underrepresented groups in STEM. Additionally, this work should focus not on comparing these groups to majority group members but instead on the strengths that children from underrepresented groups already have.

Finally, research with older children, adolescent, and adult populations could be leveraged to paint a stronger developmental picture of how people's beliefs about ability and intelligence, their science motivation and interest, and their persistence change over time. Understanding how this developmental trajectory plays out could be very useful in considering developmentally appropriate interventions in early childhood. For example, Ma et al. (2022) found that adults do not show as strong a bias for individuals with natural ability as four- to seven-year-old children, indicating that at some point in development this bias fades. It seems possible, therefore, that the bias we see in Paper 2 for the Ability Informant might also fade by adulthood. This type of developmental finding would allow researchers to ask more pertinent research questions, such as what factors lead this bias to fade and how to intervene earlier in development to reduce such a bias.

Conclusion

Taken together, these three studies provide a new perspective on the influence of visual and linguistic cues on children's STEM persistence, interest, and beliefs. The research in this dissertation furthers our understanding of how visual and linguistic cues to group membership influence children's beliefs and behaviors in the domain of STEM. The fact that this work is focused on the domain of STEM has implications both for our basic understanding of children's responses to highly stereotyped social groups and for our understanding of how caregivers and educators can motivate children to participate in STEM activities. Additionally, there are important future directions of this work, including fostering STEM motivation and engagement in young children from underrepresented groups in STEM, unpacking constructs like ability and effort that are more complex than they seem at first glance, and conducting interventions in early childhood educational settings.

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